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The Relationship between Science Curriculum Aligned to Common Core State Standards and Scientific Literacy

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Abstract

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MS, Biology, University of Arizona, 2011

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Abstract

Supporting the development of scientifically literate students is a priority in public school education, and understanding how that development is influenced by the Common Core State Standards is vital to quality science education. However, little quantitative research has been conducted about how the Common Core State Standards impact science education. The purpose of this quasi-experimental study was to determine how the alignment of science curriculum and instruction to the Common Core English Language Arts State Standards impacts the development of students' scientific literacy skills. Bybee's framework for scientific literacy provided the theoretical framework. Participants included 7 middle school students in Grades 5-8 in a rural community located in the western region of the United States. The summer school science intervention teacher integrated Common Core English Language Arts Standards into a biological science curriculum developed by Marsh. Scientific literacy was determined by student results on released items from the 2011 Trends in International Mathematics and Science Study. Results from assessments in this study indicated an improvement of 5.5% when comparing pre to posttest scores in scientific literacy, though not statistically significant when analyzed using ANOVA. Recommendations include a need to increase research in rural education about scientific literacy for K-12 students, and about the impact of Common Core State Standards on science instruction. This study contributes to positive social change by providing educators and researchers with a deeper understanding of how to improve science literacy for all students.

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Chapter 1: Introduction to the Study

The National Research Council (2007) asserted that education should promote science as a necessary aspect of human thinking, provide experiences in logic and problem solving, and support the development of informed citizens. Science is learned by combining kinds of meaning with degrees of meaning, each influencing the other. Understanding science requires individuals to integrate and apply many types of knowledge, such as facts and information, ideas, relationships, and reasons (Pratt & Pratt, 2004). Core concepts of learning within science integrate personal value, political understanding, application to human history and culture, reflection, and enriching knowledge (DeBoer, 2000).

Humans created the discipline of science so that individuals could understand the physical phenomena of the natural world, and they created the discipline of English language arts to comprehend text and the spoken word (Pratt & Pratt, 2004). Scientific literacy is defined as the various skills and knowledge necessary to obtain a foundational understanding of how scientific information is developed, how the process of science is done, and how to separate scientific facts from a variety of kind of information (Impey et al., 2011). Scientific literacy is not exclusively the knowledge of scientific concepts and facts; it also is the ability to make individual meaning with concepts, relationships, representations, and processes (Lemke, 2004). The Next Generation Science Standards (2013) suggested that scientifically literate individuals can be developed by focusing on the four main concepts of life science, physical science, earth and space science, and science as an engineering process.

In the early 1950s, scientific literacy was associated with the discussion of basic education within science (Cohen & Watson, 1952). DeHart Hurd (1958) introduced the use of scientific literacy as an understanding of science and its value to society. The focus on science in the 1960s was to prepare future scientists and provide knowledge background for the general population (Bybee, 1997). The focus on science education began in the late 1950s with the development of physics, chemistry, biology, and earth science curriculum. The National Defense and Education Act (1958), which later developed into the Elementary and Secondary Education Act (1965), emphasized the development of scientific principles within education for national security purposes. With the drive to fill professional positions in science and engineering, traditional instructional approaches supported quick instruction of students on scientific content. Traditional science instruction consists of lecture, discussion, and recitation. Traditional perspectives of science education have emphasized the presentation of science as a body of information created by scientists for memorization (Fang & Schleppegrell, 2010).

A new vision of science education places a higher emphasis on cognitive abilities and less on the skills of observing, inferring, classifying, and forming hypotheses (Bybee, McCrae, & Laurie, 2009). The perception of science that society holds has significantly impacted science education policies, programs, and practices. Scientific literacy is more than understanding the concepts of scientific disciplines; a need also exists to understand the social context, nature, and processes of science. Achieving science for all members of society includes developing personal growth, understanding the individual role within society, and pursuing quality employment (Bybee et al., 2009).

Historically, educators in the United States have provided minimal opportunities for students to learn science and limited exposure to science literacy development for the general public while nurturing those students with scientific potential (Stage et al., 2013). Reform requires addressing the whole system in regards to science education. A significant need, therefore, exists to focus on science learning for all students, including the provision of positive learning conditions with community support, as described in the *Science for All Americans* project (Rutherford & Ahlgren, 2013). The American Association for the Advancement of Science (AAAS) developed one of the first projects focused on developing scientific literacy, and it influenced the development of nationalized science standards that included scientific knowledge for the general public (Rutherford & Ahlgren, 2013).

Science educators have realized that it is unwise to focus on the structure of the various scientific disciplines at the expense of the needs of students (Worth et al., 2009). Science instruction should include comparisons of scientific thought, comparisons of various sciences, the relation of science to the past, and the use of science within society. Positive scientific attitudes, such as persistence and curiosity, help to motivate learners to engage in challenges with personal interests. It is a challenge to support both the intellectual understanding of the natural world and the utility of science for the individual (Worth et al., 2009).

This chapter is an introduction to the study. It includes background information related to the research scope of the study, the problem statement, the purpose of the study, and the research questions. In addition, this chapter includes the theoretical framework of the study, an overview of the nature or methodology of the study, definitions, assumptions, scope and delimitations, and limitations. This chapter also includes a brief discussion of the significance of the study, including implications for social change, and a summary.

Background

A steady decline in students' attitudes towards science occurred in the last four decadesonce it became a required subject of study (Bennett, 2003). The emphasis on developing scientific literacy began to move away from addressing understanding science that is specific for future scientists and towards the development of understanding science that is necessary for all citizens (Millar, 2008). The majority of citizens will not be producers of new scientific knowledge, but they will be consumers of scientific knowledge and information.

An understanding of scientific inquiry and its connection to the nature of science is considered a key aspect of scientific literacy (Roberts, 2007). The epistemology of science is a way of knowing and understanding the world (Gyllenpalm, Wickman, & Holmgren, 2010). Any inquiry activity in a science classroom should be associated with specific language arts skills in speaking, listening, writing, and reading (Yore, Bisanz, & Hand, 2003). These English language arts activities should also address the development of scientific knowledge, as well as the purpose, audience, style, and role of the writer in relation to scientific writing (Gyllenpalm et al., 2010).

This study was needed because integration of scientific literacy is a vital part of science education. The Common Core State Standards do not specifically emphasize scientific literacy and the nature of science. Therefore, educators face a challenge in understanding what is meant by the nature of science and scientific inquiry and how they can be communicated to K-12 students (Lederman, Lederman, & Antink, 2013). Educators need a functional understanding of the nature of science and scientific inquiry in order to improve science teaching and learning.

A gap in the research exists about the influence of the Common Core State Standards on science instruction, including their impact on scientific literacy. This research gap may be due to the recent adoption of the Common Core State Standards across the United States and the resulting emphasis on the integration of these standards into classroom instruction. With this adoption, K-12 science teachers are also required to integrate the Common Core English Language Arts (ELA) State Standards into science curriculum and instruction, and they are required to assess student proficiency in relation to these standards by administering state science assessments. Limited research exists on the integration of the State Science Standards and the Common Core ELA State Standards into science curriculum and instruction in order to improve the reading comprehension skills that students need to understand informational text. Therefore, in this study, I addressed the research gap by analyzing the alignment of science curriculum for students in Grades 5-8 to the Common Core ELA State Standards and how the integration of these standards into science instruction affects the scientific literacy of students enrolled in a middle school located in a rural community in a western state.

Statement of Problem

Not enough research is available to determine how the integration of Common Core ELA State Standards affects scientific literacy. Researchers have indicated a need to improve science instruction in order to support and improve scientific literacy development. Norris and Phillips (1994, 2003) found that students who were considered among the top science students in the country performed poorly on scientific literacy skills, such as interpreting everyday media reports on science. In a 20-year survey of science literacy, Impey et al. (2011) found that belief in pseudoscience among undergraduate students is high and does not correlate with their knowledge of science. Additional studies that use Bybee’s theoretical scale of scientific literacy are needed to guide research about the measurement of scientific literacy during the instructional process (Shwartz, Ben-Zvi, & Hofstein, 2006). In this study, I addressed rural science education, an area already in need of high quality research, as well as the need to support scientific literacy in education (Arnold, Newman, Gaddy, & Dean, 2005; Impey et al., 2011).

Limited research is available about how the Common Core State Standards affect science instruction. With the integration of the Common Core ELA State Standards into science curriculum and instruction, a more disciplinary focus on literacy instruction may result (Guthrie et al., 2004). Educators hope that the implementation of the Common Core ELA State Standards will help students to master and apply reading and writing skills in various content areas other than ELA, but limited research exists in this area at this time (Guthrie et al., 2004). Research is also not sufficient in exploring the effectiveness of disciplinary literacy for improving literacy achievement or subject matter comprehension in areas such as science (Shanahan & Shanahan, 2012).

Purpose of Study

The purpose of this quantitative study was to determine how the alignment of curriculum in the content area of science to the Common Core ELA State Standards impacts the scientific literacy of students in Grades 5-8 in a rural middle school. Results of this study provide insights into the relationship, if any, between the alignment of science curriculum to the Common Core ELA State Standards and the scientific literacy levels of students receiving this aligned curriculum and related instruction. Results of this study also provide insights into how curriculum alignment to the Common Core ELA State Standards influences scientific literacy for students, which is considered the primary focus of science instruction. In addition, I determined if there was a correlation between scientific literacy and the integration of the Common Core ELA State Standards into science curriculum and instruction. Research issues associated with this study include the challenges of rural education, student achievement of scientific literacy, and the integration of the Common Core ELA State Standards into science curriculum and instruction.

Research Questions and Hypotheses

RQ1: What is the relationship between the Common Core ELA State Standards and scientific literacy?

$H_0 1$: There is no significant relationship between the Common Core ELA State Standards and scientific literacy.

$H_1 1$: There is a significant relationship between the Common Core ELA State Standards and scientific literacy.

RQ2: What is the relationship between an intensive science intervention and scientific literacy?

$H_0 2$: There is no significant relationship between an intensive science intervention and scientific literacy.

$H_1 2$: There is a significant relationship between an intensive science intervention and scientific literacy.

RQ3: Does teacher integration of the Common Core ELA State Standards into an intensive intervention affect scientific literacy?

$H_1 3$: Teacher integration of the Common Core ELA State Standards into an intensive intervention does not have an effect on scientific literacy.

$H_1$3: Teacher integration of the Common Core ELA State Standards into an intensive intervention has an effect on scientific literacy.

Theoretical Framework

The theoretical framework for this study was based on Bybee's (1997) comprehensive theoretical scale of scientific literacy. In this framework, Bybee introduced the levels at which individuals understand the scientific aspects of the natural world and provided a method of identifying their depth of scientific understanding. Each level of the scale progresses in depth of knowledge and understanding, from no scientific comprehension to an in-depth understanding of science. The scale begins with the lowest amount of scientific understanding, scientific illiteracy, followed by limited understanding, described as nominal scientific literacy. Intermediate scientific understanding is expressed as functional scientific literacy, and a more complex level is defined as conceptual scientific literacy. The highest level of comprehension of science is multidimensional scientific literacy (Bybee, 1997).

Previous researchers have articulated the application of this scientific literacy framework. Soobard and Rannikmae (2011) assessed students' scientific literacy in Grades 10 and 11 in multidisciplinary scenarios and by using Bybee's (1997) framework for scientific literacy. Soobard and Rannikmae found that 54%of the students performed at the functional level for scientific literacy. Only 4% of students demonstrated the highest level of scientific literacy, which is multidimensional (Soobard & Rannikmae, 2011). In a study about integrating literacy and science in biology, Greenleaf et al.

(2011) found improvement in students' scientific literacy and in their use of inquiry biology. Students in this study also performed better on state standardized assessments of ELA, reading comprehension, and biology (author, year). Because the emphasis of instruction in many educational settings has moved towards assessing the alignment of the Common Core State Standards to instruction, in this study, I explored the impact of such curricular and instructional changes on the scientific literacy skills of students.

Nature of the Study

For this quantitative study, I selected a quasi-experimental design. This research design is consistent with determining if there is a correlation between scientific literacy and the integration of Common Core State ELA Standards into an intensive intervention through a science-themed summer school experience. Educators at the research site developed an intensive intervention curriculum for science, and one of the teachers employed by that district implemented it during the summer of 2014. The educators at this research site believed that this intervention curriculum is aligned to the Common Core ELA State Standards because a variety of literacy activities have been integrated into the science curriculum and instructional activities.

The goal of scientific literacy is to lead the general public to learn about science and other associated endeavors. Bybee's (1997) theoretical scale of scientific literacy scale was used to determine the depth of student comprehension of science content both before and after the science intensive intervention that teachers have aligned to the Common Core ELA State Standards in a rural middle school environment. The primary purpose of this study was to determine how the alignment of curriculum in the content area of science to the Common Core ELA State Standards impacts the scientific literacy of students in a rural middle school. The results of this study could also influence the development of scientific literacy at the societal level. This impact was determined by investigating a summer school experience in which the Common Core ELA State Standards have been integrated into an intensive science intervention.

This study was conducted in a rural middle school. The nature of this study was quantitative. The variables of this study included the integration of the Common Core ELA State Standards, which were measured by pre and posttests as the single independent variable and the scientific literacy of students as the dependent variable. Scientific literacy was measured using released scientific literacy test items from the Trends in International Mathematics and Science Survey (TIMSS, 2011) that is aligned with Bybee's (1997) theoretical scale of scientific literacy (Martin, Mullis, Foy, & Stanco, 2012).

Analysis of variance (ANOVA) and a Likert scale for teacher determination of the level of lesson alignment to the Common Core ELA State Standards were used to determine the correlation between the scientific literacy of students and the integration of the Common Core ELA State Standards into a summer school intensive intervention in science that a middle school science teacher developed. A statistical analysis of assessment data on scientific literacy was also presented. This research method supports the purpose of this study by providing evidence to determine if the alignment and integration of the Common Core ELA State Standards into science instruction correlated with students' scientific literacy in a rural middle school environment. Individual student's scientific understanding was assessed with the 2011 TIMSS, which is aligned to the framework of Bybee's (1997) theoretical scale of scientific literacy.

Definition of Terms

Alignment: The degree to which the components of an education system, such as standards, curriculum, assessments and instruction, work together to achieve desired goals (State Department of Education, 2011).

Common Core State Standards: The Common Core State Standards (CCSS) are an initiative by the National Governor's Association and the Council of Chief State School Officers to focus attention on reading and writing across the curriculum (National Council of Teachers of English, 2011). The purpose of the CCSS is to improve student outcomes, standardize opportunities for learning, and focus on fewer and more rigorous, benchmarked standards (Conley, 2014).

Common Core ELA Standards: The Common Core ELA State Standards focus on reading, writing, speaking, and listening as well as the integration of literacy standards in history and social studies, science, and technical subjects (Conley, 2011).

Intensive intervention: This intervention is designed to address learning challenges that K-12 students face. These types of interventions are characterized by increased intensity in instruction, such as smaller groups or increased time, to provide academic support within content areas (National Center on Intensive Intervention, 2014).

Scientific literacy: An individual's scientific knowledge and use of that knowledge to identify questions, to acquire new knowledge, to explain scientific phenomena, and to draw evidence-based conclusions about science-related issues; understanding of the characteristic features of science as a form of human knowledge and inquiry; awareness of how science and technology shape material, intellectual, and cultural environments; and willingness to engage in science-related issues, and with ideas of science, as a reflective citizen (Highlights from PISA as cited by Monahan, 2012).

Assumptions

This study was based on several assumptions. One assumption was that scientific literacy can be assessed with science achievement tests. Scientific literacy addresses the understanding of the nature and processes of science, which may not be accurately assessed through standardized tests. In order to fully assess scientific literacy, researchers have argued that assessments should engage students in authentic experiences that encourage the application of science skills (Lederman, Lederman, & Antink, 2013). This assumption was important to this study because it provided quantitative data to measure the depth of scientific literacy of students.

Another assumption of this study was that teachers who implement a science curriculum that encourages students to do science activities will improve their scientific literacy skills. However, the idea that the act of doing science will translate into understanding the nature of science and scientific inquiry has been contested (Lederman et al., 2013). Other researchers believe a quality science education experience plays a significant role in improving students' scientific literacy skills (Duan, Xu, & Liu, 2013). This assumption was important to this study because the majority of science instruction focuses on engagement and the transmission of information, thereby increasing scientific literacy, through science activities.

Scope and Delimitations

1. The science curriculum that the teacher used for the intensive intervention was aligned to the Common Core ELA State Standards,
2. Scientific literacy was assessed using released items from the TIMSS.
3. The population for this study included middle school students in a rural community who voluntarily participated in a science intensive intervention during summer school.
4. Due to the small population of the middle school in this rural community, the number of student participants represented an adequate sampling of students in the rural community.
5. Bybee's (1997) framework for scientific literacy was used as the theoretical framework for this study.
6. The choice of reading selections, including textbooks and supplemental instructional material, were examined in this investigation.
7. The teacher's instructional approach was not investigated during this study.

Limitations

1. This study was limited to a single middle school in one public school district located in a rural community in a Western state.
2. Student participation in the intensive science intervention was voluntary, so the sampling of students did not represent the population of students within this rural community. All students in this middle school were invited to attend the science summer program, but participation was voluntary.
3. This study was limited to one teacher's science instruction during one intensive intervention for 4 hours per day, 4 days a week, for 4 weeks.
4. This study was limited to a middle school population, Grades 5-8, in a single elementary school in the district.
5. The teacher who provided the intensive intervention in science was an employee of the school district and was familiar with students in the study.
6. I was not the teacher for the intensive intervention in science. The administrator at the cooperating school selected the teacher who provided the intensive science intervention, and therefore, I was not associated with the selection process or the teacher who provided the intensive intervention.

Significance

The significance of this study is that it advances knowledge in science education, specifically in scientific literacy. Scientific literacy includes a capacity to build a future understanding of science and knowledgeable citizens who understand how the process of learning science and technology develops (Aikenhead, Orpwood & Fenshman, 2011). One of the specific areas of science addressed in this study was rural science education, an area already in need of high quality research as well as the need to support scientific literacy in education (Arnold et al., 2005; Impey et al., 2011).

This study was also significant because it contributed to improving practice and policy in science education. Educators are focused on implementing the Common Core State Standards throughout the United States, and in this study, I explored how such a policy may impact the instruction of content areas such as science. The results of this study provide insight into how alignment of science curriculum with the Common Core ELA State Standards impacts the scientific literacy levels of students. The results of this study also provide insight into how curricular alignment with the Common Core ELA State Standards influences scientific literacy, which is considered the main focus of science instruction.

Impact on Social Change

This study contributes to positive social change by advancing research about rural educational environments to support the development of more equitable science experiences for all students. Students in urban communities perform significantly higher on standardized scientific literacy assessments than students in rural areas (Thomson et al., 2010). By investigating different educational environments, such as rural schools, it is possible for researchers to support scientific literacy awareness and development for all educational environments. Education is the primary means of social change (Bybee, 1997). Citizens of the United States do not have a strong understanding of major concepts and skills related to science, technology, engineering, and mathematics (Augustine as cited in Khasnabis, 2008; Symonds, 2004). One concern within the development of scientific literacy is that general science knowledge could become devalued as a result of pressing technological issues, even though those same issues are addressed within science and society (DeBoer, 2000). Therefore, this study contributes to positive social change by helping members of society understand that they must provide fiscal, intellectual, and political support for science education by valuing scientific literacy and helping all students achieve a reasonable level of scientific literacy.

Summary

This chapter provided an introduction to the study. Background information was presented in relation to a summary of current research, an explanation of the research gap, and a discussion about why this study should be conducted. The nature of this study was quantitative, and a quasi-experimental design, using a one-group pretest-posttest design that Shadish, Cook, and Campbell (2002) recommended, was selected. This research design was appropriate for determining if a correlation existed between scientific literacy and the integration of the Common Core State Standards into an intensive summer school intervention in science. The educators at the rural middle school developed the science curriculum for this intensive intervention, and one of the teachers employed by that district implemented this curriculum during the summer of 2014. This research design supported the main research question of this dissertation by providing evidence to support the hypothesis that the Common Core ELA State Standards have been integrated into science curriculum and instruction in order to improve scientific literacy skills for students in Grades 5-8 in a rural middle school. Bybee's (1997) theoretical scale of scientific literacy formed the theoretical framework for this study. This scale was used to determine the depth of student comprehension of science content both before and after the presentation of instructional material aligned to the Common Core ELA State Standards in an intensive science intervention. In addition, this chapter included a statement of problem, the purpose of study, and the research questions and hypotheses. The theoretical framework, the nature of study, definition of terms, assumptions, scope and delimitations, limitations, significance, and the impact on social change were also described.

Chapter 2 includes a review of the literature in relation to the conceptual framework, rural education, and the Common Core State Standards, with a focus on the Common Core ELA State Standards, and scientific literacy and its development through literacy skills. In addition, major themes and gaps in the research are discussed, as well as how this study addresses these research gaps.

Chapter 2: Literature Review

A lack of research exists about the influence of the Common Core ELA State Standards and scientific literacy. Norris and Phillips (1994, 2003) found that high ranking science students in the United States performed poorly on scientific literacy skills, such as interpreting scientific media directed at the general public. An achievement gap exists between socioeconomic and racial groups of students in science. Minority student populations and low socioeconomic status students also perform poorly on examinations that assess scientific literacy, such as the TIMSS (Monohan, 2012). Therefore, the purpose of this study was to determine how the alignment of instruction in the content area of science to the Common Core ELA State Standards impacts the scientific literacy of middle school students in a rural environment.

In relation to rural education, scholars indicate a need for more science education research in rural areas (Boyer, 2006; Oliver, 2013; Thomson et al., 2010). A need also exists to support a curriculum that meets the needs of the local community, but which still addresses the national and state standards. One such national expectation for rural communities is the Common Core State Standards, which are a new initiative. The full influence of this initiative is still to be determined (Coleman & Pimentel, 2012; Conley, 2011, 2014; Townsend & Collins, 2009). These new standards emphasize literacy skills, including content areas such as science that do not traditionally focus on these skills. The effectiveness of the Common Core State Standards will be determined to some extent by assessments that include measures of scientific literacy, such as the TIMSS (Conley, 2014). Concerns have been expressed, however, that science instruction will move towards supporting literacy skills rather than the development of scientific understanding (Conley, 2014). With a renewed focus on the development of literacy skills through the Common Core State Standards, the potential for a significant impact on science education exists (Conley, 2014).

There is a need to improve the scientific literacy skills of K-12 students in order to create a highly educated and informed U.S. society (Bybee et al., 2009). In order to support scientific literacy, educators should encourage student engagement with experimental explorations in science activities so that students are able to develop an understanding of scientific content and to clearly communicate their observations and ideas. More research is necessary to determine the relationship between instructional strategies, scientific content knowledge, and beliefs about science (Impey et al., 2011). Supporting the improvement of literacy skills through science instruction will help students develop the language and communication skills that they need to engage in the act of science (Shanahan & Shanahan, 2012). Research about intensive interventions in science that emphasize literacy skills can determine if such interventions are beneficial in the development of scientific literacy and literacy skills for K-12 students.

In this chapter on a review of the research literature, I describe my literature search strategy and the theoretical framework for this study. In addition, I analyze and synthesize research related to the following topics: (a) rural education and the need for science research in rural communities; (b) an examination of the Common Core ELA

State Standards as they relate to science education; (c) further explication of definitions related to scientific literacy and how it is developed through science instruction; and (d) the need for literacy instruction in science, particularly for middle school students who live in rural environments. I also discuss the major themes and gaps that emerge from this literature review and how this study addresses those gaps.

Literature Search Strategy

Several search strategies were used to conduct this literature review. Google Scholar was used as the primary search engine. Databases that provided a variety of resources included the Educational Resources Information Center (ERIC), Education from SAGE, and What Works Clearinghouse. I focused on peer-reviewed journal articles published between 2009 and 2014, with some significant prior research. Key words included *scientific literacy, science educational policies*, and *scientific literacy theories*. Additional key words included *Common Core State Standards*, *Common Core ELA Standards*, *cross-curricular literacy instruction*, *disciplinary literacy*, and *educational policies and literacy integration* in various content areas. Other key words included *science education in rural communities, educational research in rural schools,* and *interventions in rural schools*.

Theoretical Framework for Scientific Literacy

The theoretical framework for this study was based on Bybee's (1997) comprehensive scale of scientific literacy. In this framework, Bybee provides a description and a method of identifying of how what individuals understands how science explains the natural world. Each level on the scale increases the depth of scientific understanding, beginning with no scientific comprehension to a thorough and detailed level of scientific knowledge. The lowest level on the scale of scientific literacy is scientifically illiterate, next is nominal scientific literacy. Functional scientific literacy is the mid-level of understanding on the scale and a higher level of understanding is identified as conceptual scientific literacy. The high level of scientific understanding on the scale of scientific literacy is described as multidimensional scientific literacy.

The first level of Bybee's (1997) theoretical scale for scientific literacy begins with scientific illiteracy. Scientific illiteracy occurs because of factors related to age, stage of development, or disabilities. When individuals are asked a question related to science, Bybee contended that they do not possess the cognitive abilities to understand the question itself or locate it within a specific domain of science.

Nominal literacy, Bybee (1997) maintained, is the second level of scientific literacy, and it is present in individuals who understand a term, question, or topic is scientific in nature, but they are unable to expand on the topic. At this level, individuals express a basic understanding of observed phenomena. Students at this level demonstrate minimal understanding of scientific concepts, with little or no relationship to real understanding. These students associate scientific words and ideas, Bybee argued, but they represent misconceptions, naïve theory, or inaccurate conceptions.

Individuals at the third level of Bybee's (1997) scale of theoretical scale of scientific literacy are functional scientific literate and are able to use scientific vocabulary, but only in a specific context such as defining terms or listening or reading general public information about science. Their knowledge lacks conceptual details of the disciplines and focuses on memorized information. Students who demonstrate functional scientific literacy, Bybee contended, respond appropriately to vocabulary associated with science; however, they demonstrate little knowledge of concepts, principles, laws, and theories or the fundamental procedures of scientific inquiry.

The fourth level of Bybee's (1997) scale of scientific literacy, conceptual and procedural scientific literacy, occurs when individuals understand how various concepts in a discipline relate to the discipline as a whole and to the methods associated with inquiry. Students who express conceptual and procedural scientific literacy demonstrate understanding of both the parts and whole of scientific disciplines. These individuals, Bybee contended, are able to identify appropriate problems, design, implement, and evaluate solutions, and communicate their conclusions.

The fifth and final level of Bybee's (1997) theoretical scale of scientific literacy is multidimensional scientific literacy. This level of scientific literacy occurs when individuals are able to expand on the philosophical, historical, and social dimensions of a scientific discipline. Students who have reached multidimensional scientific literacy understand the conceptual structures of science, including the nature of science and the relationship of science to society. At this level, Bybee noted, individuals express integral and contextual literacy in science. Integral literacy means individuals have an essential conceptual understanding, while contextual literacy is present when individuals can see the relationship between the various disciplines in science in relation to personal and societal challenges. Multidimensional scientific literacy is a challenge to achieve, Bybee maintained, because individuals express a high level of literacy in relation to a specific topic, while expressing a low level of literacy in relation to other topics.

Bybee (1997) proposed this theoretical scale of scientific literacy to illustrate that science literacy is continuously distributed across all members of society. Educational standards influence the content and threshold for scientific literacy. The framework that Bybee introduced is a continuum of development as individuals' scientific understanding becomes deeper and more sophisticated. This scale for scientific literacy represents a taxonomy related to program development, as well as a guide for curriculum and instruction. The dimensions of scientific literacy should not be interpreted as development stages or instructional sequences, Bybee argued, but as different aspects of knowledge, ability, skill, and understanding in relation to scientific literacy. However, Shamos noted that some researchers believe that scientific literacy may be an unachievable goal, and therefore, it is detrimental for educators to focus on scientific literacy in order to improve science education (as cited in Bybee, 1997).

The framework for scientific literacy that Bybee (1997) developed is useful for science educators to consider in developing a strategic plan for improving scientific education, evaluating scientific educational reform, and assessing the outcomes of various aspects of scientific educational reform. This framework has both vertical and horizontal applications to instruction. Horizontal integration includes introducing more vocabulary and developing a higher level of scientific literacy. Vertical integration includes building detailed understanding of specific scientific concepts. No individual can achieve full scientific literacy, Bybee contended, but the framework provides a means to identify and develop skills that the individual needs to master in order to improve his or her scientific literacy within specific disciplines and in relation to his or her understanding of specific concepts.

Significant research has been conducted in relation to Bybee's (1997) scale of scientific literacy. In earlier research, Shwartz, Ben-Zvi, and Hofstein (2006) explored the use of a scientific literacy taxonomy for assessing the development of chemical literacy among high school students, and they found that dramatic improvement in students' nominal literacy skills is possible through advanced instruction that includes some aspects of functional and conceptual scientific literacy within a discipline. Basic level instruction of some scientific content, however, does not have an impact on the nominal scientific literacy of the students. Shwartz et al. suggested that science teachers should emphasize the main ideas of science text, the relevance of scientific information, and the organization of the instructional material, and they should focus on higher order learning skills and student interests to improve their scientific literacy skills within specific scientific disciplines.

In other research related to scientific literacy skills, the National Research Council (NRC, 2014) noted that the guiding principles of effective science instruction should include addressing preconceptions, introducing what it means to do science, and teaching student to utilize metacognitive skills during the learning process. Multiple aspects are involved in how students learn science. Students build knowledge and understanding about what they already know or believe. Students must formulate knowledge by modifying and refining concepts as well as adding concepts to what they already know. The NRC also noted that the process of understanding science is more than knowing facts; it is utilizing them in a conceptual framework. Learning is mediated by the social environment where learners interact with others. Transference of knowledge, or the ability to apply knowledge to new situations, is affected by how much students understand in a variety of contexts. Taking knowledge learned from one situation and applying it to another helps students develop a better understanding of the scientific information that the teacher has presented. In a discussion of integrating science and literacy instruction with the common goal of learning science content, Pratt and Pratt (2004) maintained that effective learning also requires that students take control of their learning experience.

Traditional science education, with its emphasis on the memorization of facts, does not address scientific literacy thoroughly, which leads to a lack of scientific understanding and authentic scientific exploration (Norris & Phillips, 2003). The purpose of this study, therefore, was to determine the relationship between a science curriculum aligned to the Common Core ELA State Standards and the scientific literacy of students in Grades 5-8 in a rural middle school. In order to support the development of scientific literacy for all students, educational stakeholders must understand the need for science education and its influence on society.

Rural Education

Because this study was conducted in a community with a population of less than 500, research related to rural education needs to be considered. The research literature revealed several definitions for rural education. The United States Census Bureau (2010) classified as urban all territory, population, and housing units located within urbanized areas (UA) and urban clusters (UC) with a population between 2500 and 50,000. UAs and UCs were defined using the same criteria. The Census Bureau data delineated UA and UC boundaries that represent densely developed territory, encompassing residential, commercial, and other nonresidential urban land uses. The United States Census Bureau defined rural as all territory, population, and housing units located outside UAs and UCs. For the 2010 Census, the United States Census Bureau applied urban and rural classifications to the 50 states, the District of Columbia, Puerto Rico, American Samoa, Guam, the Commonwealth of the Northern Mariana Islands, and the U.S. Virgin Islands. Rural schools are challenging research locations due to factors such as geographic isolation, limiting funding for research, and a lack of adequate controls or comparison groups in small populations (Arnold et al., 2005). In other research, the U.S. Department of Agriculture (2000) defined a rural community as "any area of the United States, its territories and insular possessions...not included within the boundaries of any incorporated or unincorporated city, village or borough having a population exceeding

5,000 inhabitants" (p. 316). The rural and commuting-area taxonomy definition of rural is a range of areas where the population is less than 2500 (Morrill, Cronmartie & Hart, 1999).

Some prior research has also been conducted about policies and practices in rural education. In a report on the National Science Foundation's program titled the Rural Systemic Initiative, Boyer (2006) explored building community by reforming mathematics and science education in rural schools and found a need to support performance on standardized tests in rural communities and encourage enrollment in advanced and college courses. Boyer also found that barriers related to rural education include poverty, isolation, and a lack of highly skilled jobs and rural schools are often disproportionately at the bottom in relation to funding and numbers of students in attendance. In an examination of the condition of rural education research, Arnold et al. (2005) found that a steady migration of successful graduates from rural communities to urban areas and clusters has also occurred. In addition, rural youth often experience greater conflict between their personal goals and a desire to remain within their community. Turnover rates of educators, Boyer (2006) contended, continue to be high in rural communities as salaries remain disproportionately low due to the lower financial status of the rural areas where these schools are located. Therefore, making science meaningful for a rural community is challenging, and it must reflect the knowledge and values of the local community. Rural educators must also align their local curriculum with state and federal standards, Boyer contended, as well as calibrate their instruction to the social and economic needs of the rural areas in which they teach. Factors that must be taken into consideration in rural education, Boyer argued, include cultural and community integration, policies changes, data collection, standards-based curriculum alignment. Not addressing these factors can lead to incompletely taught content in areas such as science. Boyer also noted that the goal of this initiative is to improve student learning in mathematics and science as measured by standardized tests scores and student enrollment in advanced and college courses. In order to promote active learning in science, the Rural Systemic Initiative recommended that teachers integrate science kits and experiments into the curriculum to support scientific literacy for students. Additional recommendations from the Rural Systemic Initiative include informal education, such as science clubs and camps, which have been developed to address the gap in science education of rural communities (Oliver, 2013).

Other studies have shown challenges related to the instruction of science for rural students. Gilbert and Yerrick (2001) examined identity resistance and negotiation in a rural, lower track science classroom and found that students manipulate their educational environment in order to reduce the learning demands expected by the instructor of the class. A survey conducted by Lyons and Quinn (2012) found rural students enjoy school science less than students in larger communities. In a review of rural education, Oliver (2013) noted that a challenge exists in relation to providing relevance to rural students as well as quality science instruction. Additional challenges with rural education, Oliver found, include less specialization, less equipment, and less bureaucracy than schools located in non-rural settings.

A need exists to support scientific literacy in rural schools because students in rural communities do not have as high a level of scientific literacy as students in urban areas. The results of the Progamme for International Student Assessment (PISA, 2009) in Australia indicated that students in urban areas score significantly higher in scientific literacy than students in rural areas (Thomson et al., 2010). The difference in these scores for scientific literacy between students in metropolitan areas and rural areas is half a proficiency level, equivalent to a year and a half of school (Thomson et al., 2010). Instruction that supports the development of scientific knowledge must also be meaningful and valuable to the rural community (Gilbert & Yerrick, 2001).

Common Core State Standards

The Common Core State Standards (CCSS) are an initiative by the National Governor's Association and the Council of Chief State School Officers to focus attention on reading and writing across the curriculum (National Council of Teachers of English, 2011). The purpose of the Common Core State Standards is to improve student outcomes, standardize opportunities for learning, and focus on fewer and more rigorous, benchmarked standards (Conley, 2014). The mission of this initiative, which has been directed by a nonprofit organization since 2007, is to ensure that all students, regardless of their circumstances, receive a content-rich education in the full range of the liberal arts and sciences, including English language arts, mathematics, history, the arts, science, and foreign languages. The goal is that teachers and researchers work together to create instructional materials, conduct research, and promote policies that support a comprehensive and high quality education in public schools in the United States (Common Core State Standards Initiative, 2014)

The Common Core State Standards were released in 2010. The ELA standards focus on reading, writing, speaking, and listening as well as the integration of literacy standards in history and social studies, science, and technical subjects (Conley, 2011). It is the goal of the standards initiative to identify key knowledge and skills for instruction and assessment as well as improve the achievement level of K-12 students enrolled in public schools in the United States. It is also a goal to support consistent national expectations for student learning data, curriculum materials, teacher preparations programs, and research results for what works in education (Conley, 2011). The Common Core ELA State Standards is also an initiative to support the educational goals of all K-12 students. These standards have a greater emphasis on literacy in all subject areas than the previous state standards. These standards are also intended to improve reading comprehension for all students by providing a framework for how science teachers can help students learn these skills (Conley, 2014).

The Common Core State Standards have been adopted in 43 states, the District of Columbia, and all United States territories (Achieve, 2013). A total of 47 states and the District of Columbia have adopted the Common Core ELA State Standards (Conley, 2011). The implementation process has begun in these states as educators have integrated the Common Core State Standards in ELA and mathematics into the curriculum and instruction of such disciplines as science and social studies (State Department of Education, 2012). It is the goal of this initiative to integrate literacy standards into the core content areas such as science and social studies in order to support not only the development of language but scientific literacy as well (Townsend & Collins, 2009).

By adopting the Common Core State Standards, state educators are encouraged to move away from a test preparation focus towards high quality learning for all students (Conley, 2011). The instructional focus is to develop cognitive strategies and skills to support college and career success. These skills can be developed through engaging curriculum that supports students' cognitive development. The key cognitive strategies of the Common Core State Standards include problem formulation, research, interpretation, communication, precision, and accuracy. These strategies are critical in identifying key knowledge, understanding how knowledge is organized, and how cognitive complexity can be infused with knowledge (Conley, 2011).

The Common Core State Standards are intended to guide teachers and other educational professionals in developing more purposeful and strategic ways to provide instruction in mathematics and English language arts (Coleman & Pimentel, 2012). The Common Core State Standards focus on current instructional strategies that teachers should use to prepare students for future education and careers. These standards include both content and basic skills. The goal of the Common Core State Standards initiative is to motivate educators in other content areas, such as science, to build knowledge and comprehension within their content areas through reading and writing (Core Facts, 2012). Some research suggests that teachers who apply the Common Core State Standards within disciplinary literacy provide support for student development of specific content area knowledge that is relevant to academic progress (Zygouris-Coe, 2012). Language components included in disciplinary literacy are everyday language, abstract language, and metaphoric language (Fang, 2012).

The Common Core State Standards include a focus on expository text, critical reading, disciplinary literacy, text complexity, academic vocabulary, and informational text (Conley, 2014). These standards are designed to be rigorous and specific as well as teachable, learnable and measurable. The Common Core State Standards are evidence-based and aligned with college and career expectations while building on existing standards for the application of knowledge with higher order thinking skills (Conley, 2014). The Common Core State Standards initiative advocates literacy as the core of each content area and the responsibility of all educators in every content area and grade level. The specific initiative known as Writing across the Curriculum is an example of how teachers can integrate literacy skills into various content areas to support critical thinking and content specific learning. In a case study of a science class, Hoeller (2014) found that writing helps students engage with the instructional material in science, provides an opportunity for students to reflect on new concepts in science, and results in improved student grades in science.

The Common Core State Standards are also supported by research, including the Trends in International Mathematics and Science Study (TIMSS) and the Program for International Student Assessment (PISA), surveys from college and training programs, assessment data, and comparison of standards from other countries (Conley, 2014). The Common Core State Standards are based on the National Assessment on Educational Progress (NAEP) frameworks, which extensively apply research and evidence-based standards to national educational policy, including building on the 2003 Standards for Success, the American Diploma Project, and the standards of the ACT and the College Board (Conley, 2014). Teachers and standard experts across the United States provided guidance in the development of the Common Core State Standards, and adoption of these standards is a requirement to apply for the Race to the Top grants. These standards are not a curriculum, but shared goals and expectations of the knowledge and skills necessary for student success (Core Facts, 2012).

The Common Core State Standards do not define advanced work beyond a basic core of skills or the interventions that may be necessary to support students below grade level, those who are identified as having special needs, or those who are identified as English language learners (Zygouris-Coe, 2012). Concern has also been expressed as to how educators will use assessments of the Common Core State Standards for instructional accountability. Educators in states and public school districts who implement these state standards will need to review current assessments for alignment, develop tools to assist teachers in assessing literacy within their specific disciplines, and develop models for collaboration throughout content areas for reading at the secondary level (Zygouris-Coe, 2012). A need also exists for educators to improve their assessments, provide examples of formative assessments, and build databases that they can utilize to improve instruction. One approach towards supporting improved assessment and instruction, therefore, is the adoption of the Common Core State Standards because of their focus on requiring students to demonstrate knowledge through precision and detail (Coleman & Pimentel, 2012). However, some evidence exists that standards-based education has the potential to inhibit the creativity and autonomy of students and teachers (DeBoer, 2000).

Common Core State Standards and English Language Arts

The Common Core ELA State Standards require students to understand expectations for their learning and to achieve proficiency in literacy skills. These standards include specific literacy skills in reading, writing, and speaking and listening. Each of these skill areas are described below in relation to these standards.

Reading Standards

The focus of the reading standards includes supporting the ability to comprehend various types of literature, text and media, including conducting text analysis, determining main ideas, interpreting text for structure and purpose, examining claims and arguments presented in text, and comprehending complex and informational text (Common Core State Standards Initiative, 2010). The reading standards within the Common Core State Standards initiative focus on the increasing complexity of reading material as well as the development of comprehension skills to support student progress towards the demands of college and career expectations (Common Core Key Points, 2012). Students are required to read complex text and work towards independence in their understanding of these texts. Within the Common Core ELA State Standards, it is expected that at Grade 8, 45% of the reading text is literature based and 55% is informational, leading to reading texts that are 30% literacy and 70% informational by Grade 12 (Monahan, 2012). A goal of the reading standards initiative is to help students develop mature language skills and conceptual knowledge. Teachers introduce complex text with new ideas, information, and experiences, using a variety of scaffolding skills. Students who experience challenges processing difficult text, such as scientific informational text, may need assistance with comprehension skills, fluency practice, and vocabulary building (Coleman & Pimentel, 2012).

The reading standards also include a focus on providing daily reading opportunities to build knowledge and experience with reading. Instruction should include whole-group, small-group, and individual opportunities to support student responsibility and independence (Coleman & Pimentel, 2012). Reading materials should help teachers focus instruction on reading, writing, speaking, and listening in direct response to high quality text. The Common Core State Standards provide models for determining text complexity, including qualitative and quantitative dimensions (Zygouris-Coe, 2012).

Writing Standards

The focus of the writing standards includes writing clear and strong arguments supported by evidence, writing informative and explanatory text, and writing narratives. It is also the goal of the writing standards to expect students to utilize technology as a part of the research process as well as to modify their writing projects based on the audience and purpose (Common Core State Standards Initiative, 2010). The Common Core State Standards also expect students to write logical arguments based on claims, reasoning, and evidence (Stage et al., 2013). The standards for writing specifically focus on the skills of arguing and explaining (Conley, 2014). In addition, these standards focus on building arguments that demonstrate reasoning and evidence, as well as on developing research skills (Common Core Key Points, 2012). Students are expected to support their writing with sources, and they are expected to develop arguments and write to inform as well as write to a specific audience. Short, focused research projects are also required. In the middle school setting, 35% of student writing should be arguments, 35% should be to explain or inform, and 30% should be narrative (Coleman & Pimentel, 2012).

Speaking and Listening Standards

The focus of the speaking and listening standards include effectively communicating with various audiences and integrating different media and formats in order to communicate ideas as well as analyzing a speaker's presentation for points of view and use of evidence (Common Core State Standards Initiative, 2010). The speaking and listening standards also require students to present and evaluate information, ideas, and evidence. Teachers are expected to observe these skills in one-on-one, small group, and whole group settings (Common Core Key Points, 2012). Instructional material should support academic discussions and help students to develop fluency with language use and to integrate multimedia and technology experiences (Coleman & Pimentel, 2012).

Common Core State Standards and Science

Science instruction related to the Common Core State Standards incorporates multiple disciplinary ideas, practices, and crosscutting concepts (Stage et al., 2013). The Common Core State Standards for literacy in science align with test items as measured by the National Assessment of Education Progress (NAEP), with one-third of the standards focused on specific skills within science and not directly associated with literacy or mathematics. The Common Core State Standards also includes a framework for specific literacy skills, such as reading and writing related to scientific, technical, and informational text (Monohan, 2012). A challenge with the implementation of the Common Core State Standards is that teachers need to help students develop the ability to read scientific text for understanding without an emphasis on specific scientific knowledge (Monahan, 2012).

The Common Core ELA State Standards for science support disciplinary literacy (Shanahan & Shanahan, 2012). Content area literacy, on the other hand, focuses on study skills and the ability to read and write in a specific content area. A link exists between reading comprehension and scientific knowledge as introduced in the Common Core

State Standards (Coleman & Pimentel, 2012). A significant percentage of activities and questions during reading activities are focused on the written word, supplemented by various instructional approaches. The Common Core State Standards strongly focus on the expectation that students will gather evidence, knowledge, and insight. Students are expected to use the text-dependent approach in building knowledge, supporting valid inferences, and making connections with text and prior learning. Students must also build the skills, habits, knowledge, and experiences that allow them to process challenging text (Coleman & Pimentel, 2012). These skills are valuable not only in processing text, but in the practice of science itself.

As educators across the United States begin to integrate the Common Core State Standards into their course curriculum, it is necessary to determine how the impact of an instructional emphasis on literacy skills will effect knowledge development in such content areas as science. The challenge of meeting the expectations of new content standards could have a significant impact on science instruction, because science teachers may not have the same level of focus on the literacy standards as teachers of language.

Goals for Science Education

The four primary goals for science education, according to the National Research Council (2007), include (a) the ability to know, use, and interpret scientific explanations, (b) to be able to generate and evaluate evidence and explanations, (c) to understand the nature and development of scientific knowledge, and (d) to participate in scientific practices and discourse (as cited by Worth et al., 2009). These goals support students' ability to reason and engage in science. To achieve these goals, science skills for all students in the United States should be developed (NRC, 2007). These skills include scientific and engineering practices, crosscutting concepts and applications across fields within science and engineering, and a focus on the disciplinary areas of physical, life, earth and space science, engineering, technology and the application science within society.

In earlier research, Adler (1982) also described goals for science education that are essential to developing scientific literacy for the general public (as cited in Bybee, 1997). The focus of science education, Adler argued, should be on the acquisition of organized knowledge in the areas of physical, life, earth and space sciences, as well as on various unifying concepts, scientific inquiry, and technological design. Adler also maintained that teachers should focus on developing students' cognitive abilities and manipulative skills in scientific inquiry, technological design, and unifying processes. In addition, Adler believed teachers should encourage students to understand the ideas and values of science in relation to their personal lives, social challenges, historical perspectives, and the nature of science and technology.

Other earlier research also supports these goals for science education. In an examination of the historical and contemporary meanings of scientific literary and its relationship to science education reform, DeBoer (2000) noted that the goal of science and technology curriculum is to provide students with knowledge of how science and society interact and to provide instruction in the skills necessary to make decisions about science-related issues. DeBoer believed that science teachers should be free to organize science curriculum according to the many goals of science education, selecting content that is most relevant to the needs of their students. However, Bybee (1997) maintained that science teachers should also utilize objectives, content, learning experiences, methodology, and evaluation in order to support this achievement. DeBoer also contended that standards-based education has the potential to inhibit the creativity and autonomy of students and teachers in the science classroom.

In this historical perspective, DeBoer (2000) contended that science education includes the following nine goals: (a) teaching and learning science has a cultural piece within the modern world; (b) science should support preparation for employment; (c) teaching and learning science should have a direct application to everyday living; (d) students should become informed citizens; (e) learning science presents a way of understanding the natural world; (f) students need to learn skills to process reports and discussions on science in the media; (g) learning science is needed for understanding the natural world; (h) preparing citizens who are sympathetic to scientific issues is critical; and (i) understanding the nature and value of technology within science is important (pp. 591-593).

In more current research about the goals of science education, Klahr, Zimmerman and Jirout (2011) examined educational interventions to advance children's scientific thinking and the effect of direct, Socratic, and discovery instruction on student comprehension of scientific concepts. They contended that the goal of science education interventions is to support and enrich interest in scientific knowledge and procedures. Klahr et al. also maintained that scientific literacy interventions require three components: (a) a state of knowledge to be acquired, (b) a set of instructional activities that are consistent with current knowledge and learning approaches, and (c) an assessment process. In their research, they found direct instruction provided the most effective mechanism for immediate learning of science as measured by short and long term assessments and the transfer to learning to testing situations.

In a discussion of the professional knowledge base of science teaching, Fensham (2011) maintained that the goal of science education is to provide preparation for modern fields of work and stimulate the intellectual and moral growth of students. Skills such as thinking, communicating, investigating, and problem solving require context to obtain competency. Science education, Fensham noted, has a history of emphasizing repetition of previous information, explanations, or definitions rather than the active process of engaging in science. When instruction in content areas such as science focuses within itself on knowledge and assessment, Fensham contended that it avoids a lack of relevant to students receiving the instruction.

The goals of achieving scientific literacy and improving science curriculum, Bybee (1997) argued, are directly related to one another. The reality of achieving scientific literacy, Bybee noted, requires science educators to address the core issues of education, including the purpose, policies, programs, and practice of science instruction. Science instruction should include consistent curriculum, coherent instruction, congruent assessments, and continuous professional development. In order to achieve higher levels of scientific literacy, Bybee believed science educators need to work beyond explanations of curriculum, instruction, and assessment. Science educators must first identify the purpose and core values in designing curriculum and then identify the policies and strategies informing their decisions, as well as developing programs and implementing practices that are consistent with the standards.

Scientific Literacy

Literacy is the ability to read and write, as well the knowledge, learning, and education necessary to understand. Scientific literacy has been currently defined as the knowledge, learning, and education necessary to understand science (Choi et al., 2011), but multiple definitions can be found in the literature. In this section, I review the literature related to these definitions as well as the history of scientific literacy, the need for scientific literacy in American society, the goals for achieving scientific literacy, and the development and assessment of scientific literacy in K-12 education.

Definitions of Scientific Literacy

The AAAS (2013) stated that scientifically literate citizens should be aware of the strengths and limitations of science, including the unity and diversity of the natural world and the process of engaging in scientific thought. In a 20 year survey of science literacy among college undergraduates, Impey et al. (2011) noted that scientific literacy is observed in relation to a variety of factors, such as scientific vocabulary, the inquiry process, and the impact of science and technology on society. Scientific literacy is also a national goal in the fields of science and English language arts. In a discussion of science for all Americans, Rutherford and Ahlgren (2013) recommended that state governors and the Secretary of the United States Department of Education also consider scientific literacy to be a priority as they do today.

Scientific literacy is also a concept used to describe the general public's familiarity with science (Choi et al., 2011). In earlier historical research about scientific literacy, DeBoer (2000) noted that science provides intellectual training beyond deductive logic to include the inductive process of observations of the natural world and conclusion development. In a discussion about improving science literacy through an on-line professional development project, Sherwood (2007) noted that scientific literacy includes the comprehension of "big ideas" in science and the ability to utilize this information to make choices, educate, and influence others. Scientific literacy is the way in which individuals address questions related to common place occurrences and includes the ability to examine natural phenomena, to process public scientific information, and to engage in social conversation on scientific topics. Scientific literacy, DeBoer contended, is a broad and functional understanding of science beyond specific information related to scientific and technical careers.

Scientific literacy is also defined in relation to the process of scientific inquiry, which is difficult to describe outside of the context of investigation. Science requires evidence and is a blend of logic and imagination. Science explains and predicts to make sense of observations or phenomena (Rutherford & Ahlgren, 2013). Scientific habits of the mind include understanding the processes of science, critical thinking, and the scientific method (Bybee, 1997). Validation by observation is a key part of science and, therefore, the development of scientific literacy. Scientists also try to identify and avoid bias as well as conduct themselves ethically during the research process. Science is also a social activity that incorporates a body of knowledge and a way of collecting and validating knowledge that incorporates human values (Rutherford & Ahlgren, 2013).

A scientifically literate person is able to ask and determine questions that result from curiosity, to describe and explain natural phenomena, and to read and engage in conversation about science (Rutherford & Ahlgren, 2013). A scientifically literate person is also aware of scientific issues and is technologically informed, is able to evaluate the quality of scientific information, and has the ability to apply conclusions and evidence to scientific discourse (Fang & Schleppegrell, 2010). A literate person is able to function as a knowledgeable member of society (Shanahan & Shanahan, 2012). A scientifically literate citizen requires awareness of science, math, and technology, the limitations and interdependence of such, a general understanding of the natural world, and is able to use scientific modes of thought (AAAS, 2013).

History of Scientific Literacy

Scientific literacy is a term that educators and researchers have used since the 1950s to describe the knowledge of science the general public possesses. In an investigation of the historical and contemporary meanings of scientific literacy and its relationship to science education reform, DeBoer (2000) noted that a need exists for society to have highly educated citizens that understand scientific modes of thought. Scientific literacy, DeBoer contended, requires intellectual training beyond the deductive logic of formal education and that includes the inductive processes of observing and drawing conclusions. Showalter (1974) was the first to propose specific aspects related to scientific literacy, which have been modified over time, provide the basis for a more current definition of scientific literacy (as cited by Bybee, 1997), which includes the nature, concepts, processes, values, interest, and skills of science as well as the application of science in society. The Next Generation Science Standards continue this approach by separating various scientific skills and focusing on the process of doing science (Next Generation Science Standards Lead States, 2013).

Need for Scientific Literacy

A need exists to develop scientific literacy within the general population of the United States. Scientifically aware individuals have a more accurate understanding of the natural world as well as skills for logically processing and addressing various situations. Practical scientific literacy is the knowledge necessary to immediately solve practical problems (Bybee, 1997). The purpose of civic scientific literacy is to enable citizens to become more aware of science in order to support their understanding of scientific issues (Bybee, 1997). Scientific literacy is also an intrinsic quality of society that emphasizes attitudes towards science, observation, thinking processes, and the ability to solve practical problems.

Impey et al. (2011) conducted a 20 year survey of science literacy among college undergraduates and found a need to support scientific literacy in education at all levels. Impey et al. identified common misconceptions about scientists, including the idea that data and well-developed theories are always present. Impey et al. also found that those students who scored highest on the scientific literacy concepts surveys were science major undergraduates, while those students who scored lowest were education major undergraduates. Impey et al. concluded that the more students are exposed to scientific information, the less likely they are to express incorrect, nonscientific responses to scientific concepts. The results of this study also showed that the more science courses students complete, the less likely they are to express incorrect, nonscientific responses to science concepts.

Society must provide fiscal, intellectual, and political support for science instruction by valuing scientific literacy and the need for all students to achieve a reasonable level of scientific literacy. A new vision of science education places a higher emphasis on cognitive abilities and less on the skills of observing, inferring, classifying, and forming hypotheses (Bybee, 2009). The National Research Council (NRC, 2011) produced a document titled "A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas", which was utilized as a guide for the 26 lead states in the development of the Next Generation Science Standards. This framework includes science and engineering practice, crosscutting concepts, and the core ideas of scientific disciplines (Lee, Quinn, & Valdes, 2013). As presented in this publication, science, engineering, and technology are a significant part of modern life, and they require understanding and participation in policy making and daily decisions (NRC, 2012).

Goals for Achieving Scientific Literacy

Achieving scientific literacy within the content of education requires direction and focus. In earlier research about achieving scientific literary, Bybee (1997) noted that a primary goal in developing scientific literacy is to provide each citizen with a framework for public debate and discussion of science content. This framework is important to the goal for achieving scientific literacy because it encourages an informed and knowledgeable public. The essential aspect of scientific literacy includes the ability to apply scientific understanding to everyday situations. Scientific contexts are life situations involving science and technology, while scientific competencies include the ability to identify issues and phenomena use scientific evidence. Scientific knowledge Bybee contended, is the ability to understanding scientific concepts and their connection towards the nature of science, and attitudes towards science include interest, support, and responsibility towards the natural world.

The goals for achieving scientific literacy, according to the AAAS (2013), are the development of a scientific view of the world, an understanding of the scientific methods of inquiry, and an understanding of the nature of scientific enterprise. One of the methods for supporting the goal of achieving scientific literacy introduced by AAAS is Project 2061. This endeavor strives for support basic science education for all. During the first phases of the project, science experts established a baseline of knowledge, skills, and attitudes towards science (AAAS, 2013). The second phase involved the production of curriculum models for districts and states in the development of science education. The third and final phase of Project 2061, which is currently in progress, is about providing support for collaboration among scientific organizations and institutions with the goal of reforming science education nationwide.

In order to achieve scientific literacy, educators should determine and connect the content, process, and context of school-based science. In a discussion of scientific literacy for a knowledge society, Aikenhead, Orpwood, and Fenshman (2011) noted that functional science includes content that has value to those individuals who work in the science and technology fields. “Have-Cause-to-Know Science” is a type of scientific knowledge that is transmitted from experts in the science and technology fields to the general public, including problems and issues the general public encounter in relation to science and technology (Aikenhead et al., 2011, p. 11).

Scientific literacy, Bybee (1997) asserted, should be a goal for all students within a culture, based on specific standards of achievement and the ability to engage in scientific dialogue. This concept of scientific literacy has become a slogan for contemporary reform, because it unites science educators behind a statement representing the purpose of science education. Scientific literacy must be integrated into science learning that supports developing knowledge structures (Khasnabis, 2008). The understanding of scientific concepts is not beneficial in the absence of understanding the scientific processes behind the concepts. Knowledge about the practices of science are not useful in the absence of understanding the concepts that these practices are based on (Khasnabis, 2008).

Development of Scientific Literacy

The development of scientific literacy is influenced by several aspects. One aspect is that most science teachers encourage students' scientific literacy by emphasizing a basic scientific understanding of natural phenomena, scientific vocabulary, and science knowledge necessary to make decisions about science-related issues (Choi et al., 2011). Another aspect in the development of scientific literacy is the science teacher's level of awareness about the history of science education and how to contribute to the development of scientifically literate citizens (Bybee, 1997). Daugs (1970, as cited by Bybee, 1997) suggested that scientific literacy is developed through degrees of achievement, which range from limited science knowledge to a complete understanding of science.

During the development of scientific literacy, Sherwood (2007) noted, students utilize skills such as problem solving, creativity, decision-making, and scholarship, which means that science teachers need to implement science curriculum that presents these same skills. In a related study, Duan et al. (2013) explored effective ways of improving the scientific literacy of college students and found that the academic success of students was supported through scientific thinking and awareness. They concluded that students should be enriched with science content addressing the latest scientific developments, research, and applications of technology in order to improve their general academic success.

In other research about scientific literacy, Rutherford and Ahlgren (2013) noted that the AAAS originally provided recommendations for educators to support the development of scientific literacy. The AAAS has continued to support the need to develop scientific awareness among students and members of society. The AAAS also stated that scientific literacy is vital to support awareness of the natural world, the human experience, and scientific ways of thinking about individual and social purposes. The AAAS recommended that teachers help students to question nature and to engage them actively in science lessons. In addition, the AAAS recommended that students consider clarity of expression when presenting results using a team approach. In order to achieve these recommendations, the AAAS recommended that educators integrate the process of learning science by helping students understand the connections between developing understanding by exploring ideas, as well as providing them with a historical perspective about scientific discoveries and the use of technical language.

In relation to the development of scientific literacy, the research literature indicates that science educators should consider a variety of factors in order to improve student understanding of science content. One of these factors is that teachers need to utilize interpretive strategies to help students understand scientific text (Kim & Anderson, 2011). These strategies include read and response discussions, textual analysis, dialogical journal entries, multi-genre response, conceptual understanding, interpretation of text, and post reading journals (Kim & Anderson, 2011). Other interactive strategies include vocabulary building, inferring, and elaborating (Kim & Anderson, 2011). Another factor is that teachers must balance scientific literacy by utilizing effective strategies in reading, including specific instructional strategies such as identifying the main idea, predicting, writing, and summarizing (Kim & Anderson, 2011). Awareness of discourse within science curriculum provides an additional factor that influences student comprehension of science. Scientific literacy can be supported through discourse in relation to textual information, including why scientific literacy is necessary to support the continued development and understanding of scientific knowledge in an educational setting. Scientific literacy encourages informed individuals to comprehend how the natural world functions and to apply scientific processing skills through civil discourse (Bybee, 2009).

Scientific literacy is also a social construct that changes with the context and era for which it exists. Choi et al. (2011) examined the re-conceptualization of scientific literacy in South Korea for the 21st century and found that educators had developed a framework of scientific literacy skills specific to the needs of South Korea. This framework includes a focus on content knowledge, habits of the mind, character and values, science as a human endeavor, metacognition, and self-direction. This framework, Choi et al. noted, has been used to develop new curriculum, instructional materials, assessments, and professional develops towards supporting scientific literacy in South Korea.

Assessment of Scientific Literacy

The form and function of science assessments should also coincide with the form and function of science content as outlined by the standards. In a discussion of the landscape of scientific literacy, Aikenhead, Orpwood, and Fensham (2011) maintained that educational assessments have a powerful influence over the selection and implementation of science curriculum policy. They noted that the National Educational Panel Study (NEPS) created a framework for assessing scientific literacy, based on the PISA, over the lifespan of an individual. The two key worldwide assessments for gaging scientific literacy, the TIMSS and the PISA, provide either cross-sectional data or assess a specific age group of students (Hahn et al., 2013). Hahn et al. noted that educators use the TIMSS as a proxy for measuring school and system effectiveness in relation to science and mathematics education. The TIMSS is based on an analysis of the intended science and mathematics curriculum of participating countries at specific grade levels. Students who demonstrate higher achievement in science generally show a higher interest in science (Stacy, 2010). Assessment for learning focuses on individual student learning and should be designed to have a positive impact on learning (Aikenhead et al., 2011).

Literacy Skills and Scientific Literacy

The word literate has two different meanings: one is to be learned, while the others is to be able to read and write (Bybee, 1997). Functional scientific literacy is the ability to read, write, and converse about science (Bybee, 1997). True scientific literacy is when individuals have an understanding of scientific processes and concepts (Bybee, 1997). Literacy skills embrace language skills such as reading for understanding, writing and speaking clearly and developing analysis and critiquing skills to be able to read and understand various types of informational text (Thier, Daviss, & Pratt, 2002). To achieve literacy is to develop the skill of meaning-making and the act of interpretation (Saul, 2004).

Language is the principle resource for making meaning in science. Students need to be knowledgeable about scientific content, which is the derived sense of scientific literacy, but they also need to understand how to use the language and discourse of science, which is the fundamental definition of scientific literacy (Fang & Schleppegrell, 2010). Science is an endeavor that often focuses on meaning, which goes beyond natural language (Cervetti & Pearson, 2012). Some researchers believe that literacy skills are powerful when students use them in a meaningful way within a content area (Thier, Daviss, & Pratt, 2002; Khasnabis, 2008). Literacy instruction within content areas such as science need to move beyond basic skills to focus on discipline specific skills that promote engagement as well as specific use of language within a content area (Fang, 2012).

The goal of integrating literacy and science is to support students' abilities to combine literacy and science skills in order to process evidence, express ideas, and communicate understanding and decisions about the natural world (Thier, Daviss, & Pratt, 2002). In order to achieve scientific literacy, students must learn and remember science from decoding and locating information as well as develop the ability to read text from theoretical perspectives. Traditional science curriculum does not attend to the development of literacy skills as thoroughly as it should, which places students at risk of not fully understanding the significance of specific scientific knowledge (Norris & Phillips, 2003).

In this section, I review literature related to the development of scientific literacy through language skills, the integration of literacy skills into science instruction, and the relationship between disciplinary literacy and science instruction. In addition, I review literature related to literacy instruction for middle school students and studies related to vocabulary and science instruction, writing skills and science instruction, reading, and science instruction, and interventions in science that emphasize literacy instruction. I conclude this section with a discussion of the challenges that the research revealed about integrating literacy skills into science instruction.

Development of Scientific Literacy through Language Skills

Students need to improve their language skills within the content area of science in order to develop their scientific literacy skills. In earlier research on scientific literacy, Adler (1987) noted that some researchers have suggested a need to focus on basic language skills in order to support the development of informed citizens in society, even though this focus does not contribute to scientific research (as cited by Bybee, 1997). Researchers at the University of Pittsburgh and the National Center for Education and the Economy suggested that students need to master several specific literacy skills in relation to science (Thier, Daviss, & Pratt, 2002). These skills include noting details, making comparisons and contrasts, making predictions, sequencing events, linking cause and effect, distinguishing fact from opinion, linking words with meaning, making inferences, and drawing conclusions.

The need for literacy instruction in science education is critical because students need to improve their comprehension of content that is read, written, spoken, viewed, or listened to (Pratt & Pratt, 2004). Lee and Sprately (2010) found that Grade 10 students over four decades posted low scores in literacy skills on the National Assessment of Educational Progress (NAEP) . These literacy skills included engagement with the text, vocabulary, comprehension, and personal regulation of comprehension (Zygouris-Coe, 2012). Students' ability to read a novel, however, does not transfer to comprehension of specialized text as seen in content areas such as science (Zygouris-Coe, 2012). Educators need to instruct students about how to access, read, and analyze various types of text (Zygouris-Coe, 2012). Key factors that impact discipline-specific instruction include teacher development of high expectations within the classroom and instruction that is purposeful, authentic, relevant, and critical (Zygouris-Coe, 2012). The language of science is uniquely hybrid, utilizing mathematics and visual representations, with a language of meaningful, specialized skills in the process of engaging in science (Lemke, 2004).

Integration of Literacy Skills into Science Instruction

Literacy skills that are integrated into instruction have been shown to support the development of literacy skills within content areas. In earlier research, McKenna and

Robinson (1993) defined content literacy as the ability to use reading and writing in learning new content in a specific discipline such as science (as cited by Deal, 2000). A goal of content literacy is to help student develop critical thinking skill about their reading and to question inconsistencies between text and experience (Deal, 2000). The fusion of literacy and science in inquiry-based curriculum and instruction are examples of good teaching practices that benefit all students (Thier, Daviss, & Pratt, 2002). Science education methods classes should emphasize balanced content as well as literacy strategies. In more current research, several instructional strategies that science teachers use have been found to support both literacy development and scientific growth. These strategies include direct investigation, collaboration and cooperation, student to student conversation, small and whole group discussion and debate, science notebooks, access to various text and technological resources, direct instruction and modeling of skills, and scaffolding instruction towards independence (Worth et al., 2009).

Balanced literacy, in which reading and writing instruction is a part of science education, emphasizes opportunities for students to engage in the learning process. This strategy utilizes literature circles, shared reading, and interactive read a-louds during the reading process. Students learn to monitor their comprehension and to utilize various strategies to understand what they are reading (Worth et al., 2009). Science teachers should require students to make predictions and inferences that they develop from their prior knowledge. These aspects of science instruction are based on not only what students read and their prior learning, but from observations and data as well (Worth et al., 2009). Some science-specific literacy skills include separating essential from nonessential information, using visualization, and providing examples (Zygouris-Coe, 2012).

Disciplinary Literacy and Instruction

In relation to disciplinary literacy, researchers have hypothesized that supporting effective, subject specific literacy strategies and skills within content instruction will support students' literacy skills as well as the relevance of the content area itself (Conley, 2014; Shanahan & Shanahan, 2012; Zygouris-Coe, 2012). Disciplinary literacy is an approach that focuses on the specialized knowledge and language necessary to create, communicate, and use information for a specific content area (Shanahan & Shanahan, 2012). Disciplinary literacy may provide learning advantages to secondary students especially in STEM (Science-Technology-Engineering-Mathematics) professions. Students make greater progress in processing content specific text when provided specific guidance in comprehending literacy for that specific subject (Shanahan & Shanahan, 2012).

Disciplinary literacy is a learning framework that aligns with the Common Core State Standards through instruction in specific content areas such as science (Zygouris-Coe, 2012). Disciplinary literacy addresses the idea that each subject area has specific discourse with its own language, text, and ways of doing and communicating within the discipline. Literacy within the discipline is the primary goal of language instruction within content areas (Zygouris-Coe, 2012). Content area teachers, such as science instructors, will not be able to utilize disciplinary literacy without addressing how the Common Core State Standards are associated with students' reading, writing, and processing skills that are unique to science (Conley, 2014). A scientific expert must model true literacy in a content area in order to strengthen student achievement in both areas (Beaver, 2012). Pitcher, Martinez, Dicembre, Fewster, and McCormick (2010) found that skills such as vocabulary and phonics are often taught in specific content areas, but guided comprehension strategies are not.

Literacy Instruction for Middle School Students

Literacy instruction is a necessary part of learning a specific content area, such as science, in which teachers must be knowledgeable about adolescent literacy development, particularly at the middle school level (Antonacci & O'Callaghan, 2011). The design of middle schools supports the integration of literacy within content areas. Middle school grade levels provide fewer opportunities to improve reading skills than the lower grades because of the increased demand for meeting instructing content specific standards (Beaver, 2012). Adolescents experience many challenges as they develop their literacy skills, including the difficulty the text, expected literacy skills, assessments, and the disconnection between academic knowledge and outside of school experiences (Zygouris-Coe, 2012). The skills that teachers emphasize during instruction are often general, such as summarizing, predicting, and questioning, and they provide limited extension beyond content-specific text (Zygouris-Coe, 2012). A need exists to expand support for adolescent literacy development and to provide quality instruction to support their reading skills with the context of subject areas such as science. Adolescents need more targeted, comprehensive and discipline specific literacy support in all academic areas (Lee & Spratley, 2010). Teachers within content areas such as science also need to encourage adolescent students to develop and improve their comprehension skills and their in depth knowledge of those content areas (Zygouris-Coe, 2012). Major concepts in science often require the use and understanding of unfamiliar vocabulary (Weingartner, 2008). Students lacking literacy skills often have difficulty obtaining a significant portion of knowledge and comprehending data within science (Kamil & Bernhardt, 2004). Limited literacy instruction occurs in most secondary content area classes because there is an emphasis on content area instruction, and a perception that literacy instruction occurs in the English and Language Arts subjects (Weingartner, 2008). A significant challenge for secondary educators is that they are expected to be experts of content knowledge and pedagogy and also of how to support the development of student literacy skills within the content area (Zygouris-Coe, 2012). Many middle school educators also consider themselves instructors of content and not literacy teachers (Lesuax, Kieffer, Faller, & Kelley, 2010). Despite this challenge, educators need to help students understand subject matter material (Beaver, 2012).

Another challenge, Schoenbach et al. (1999) noted, is that secondary students demonstrate weak reading comprehension skills, or the ability to grasp the meaning of what is read (as cited by Thier, Daviss, & Pratt, 2002). Early reading improvement does not guarantee that students will be able to comprehend the challenging text of content areas such as science (Zygouris-Coe, 2012). Students who are introduced to a conceptual change often ignore text that conflicts with their misconceptions, they have limited understanding of technical vocabulary, they focus on unrelated facts, or they manipulate data to align it with their misconceptions (Zygouris-Code, 2012). Students also focus on completing a task rather than improving their scientific understanding of a concept. A need exists, Billmeyer and Barton (1998) contended, to train students to plan, monitor, and evaluate their reading process (as cited by Beaver, 2012). Some students also lack the self-correcting skills that most good readers use when encountering challenging text (Beaver, 2012).

One of the most critical moments in language development occurs between the ages of 9 to 13, when student move away from the grammar of written language in to the language of specific content areas (Fang, 2012). Middle school educators face the challenge of addressing the demands of science instruction while still supporting hands-on skills such as thinking, talking, and writing (Worth et al., 2009). Professional development in disciplinary literacy provides secondary science instructors with discipline-specific strategies to help students improve their literacy skills while developing their content knowledge (Lee & Sprately, 2010). Effective reform to support adolescent literacy development includes instructional approaches to support reading comprehension (Lesuax et al., 2010), particularly in relation to supporting vocabulary development for comprehending and analyzing text. Multifaceted interventions that focus on English language arts skills in middle school classrooms have been shown to improve state assessment scores for students, especially language minority learners (Lesuax et al., 2010).

The most important goal for middle school science educators is to help students develop and maintain an interest in science (Krajcik & Sutherland, 2010). The major outcomes of any school science program should be to help students learn basic science knowledge and concepts, engage students in science activities, provide opportunities for hand-on learning and problem solving experiences, and support the development of scientific reasoning (Martin et al., 1998). In an exploration of resources and instructional strategies that effective middle school science teachers used to improve content reading skills for students, Beaver (2012) found that the main reasons why students struggle with reading in science are the technical nature of the material and a lack of background knowledge about science. In addition, Beaver found that middle school science teachers implemented instructional practices commonly used in English language arts classrooms, including discussion, guided vocabulary instruction, differentiated instruction, and leveled instructional resources.

Scientific Language and Science Instruction

The language of science can be simultaneously technical, dense, abstract, metaphorical, impersonal, and authoritative (Fang & Schleppegrell, 2010). Students need to be able to take apart the language of science by translating patterns of language into everyday application (Fang & Schleppegrell, 2010). Understanding the scientific meaning of words is necessary for students who are learning the form and function of scientific language in order to develop their communicative skills in science (Fang & Schleppegrell, 2010). Students may not be able to activate and employ various language strategies due to their lack of background knowledge or their lack of proficiency in language (Fang & Schleppegrell, 2010). Reading is a form of inquiry that science teachers can use to support the language of science and scientific reasoning by utilizing primary literature (Phillips & Norris, 2009). Reading and writing is a vital part of the act of doing science in which scientists consider reading, writing, and speaking activities an essential part of their work. The language of the science classroom is similar to that of science textbooks, with an emphasis on isolated vocabulary, limited writing types, and teacher-focused discourse (Phillips & Norris, 2009).

Academic language is a highly specialized language, both spoken and written, that is used in academic settings to support communication and thinking within disciplinary content (Nagy, 2012). Academic language must convey abstract, technical, and specific ideas and phenomena. In order to engage in cognitive processes of academic thinking, as seen with scientific literacy, academic language is necessary to support communication (Nagy, 2012). Fluency in scientific language is necessary for success in academic science (Honig, 2010). Academic thinking requires dealing with systems of interconnected concepts and ideas rather than concepts and ideas in isolation (Nagy, 2012). It is unclear if assessments of academic language interventions measure disciplinary knowledge or components of academic language that could be isolated for assessment purposes (Nagy, 2012). Little evidence has been found to support the notion that current interventions support gains in academic vocabulary or improve student performance on standardized measures of reading comprehension (Nagy, 2012).

The introduction of scientific discourse in the classroom can influence student writing in science as well. Academic scientific discourse represents a specific way of knowing and thinking based on topics, attributes, events, comparisons, ideas and explanations (Honig, 2010). Fluency within science requires the use of receptive and expressive knowledge. Assessment of language is often limited to definitions of terms rather than to the use of a particular term on idea. Teachers can evaluate scientific writing by focusing on the ideas that students express, the linguistic nature of the writing, and the correct use of vocabulary (Honig, 2010). Language-based tasks that support students in their organizational and logic skills at the discourse level include developing an awareness of textual signposts, syntactic anatomy and integration, and paraphrasing. These tasks require clarifying, adding information, showing cause and effect, sequencing ideas, understanding condition and concession, and providing comparisons and contrasts (Fang & Schleppegrell, 2010).

Scientific language has certain grammatical structures that identify relationships and connections among concepts and principles (Sherwood, 2007). Developing an understanding of the structure and function of nouns in science can support student comprehension (Fang & Schleppegrell, 2010). Examples of strategies that teachers can use to support an understanding of nouns include noun deconstruction, noun expansion, noun searches, definition games, and sentence completion (Fang & Schleppegrell, 2010).

Scientific language also utilizes complex sentences with hierarchical structures that rely on different types of clauses. Comprehension problems can arise when sentences contain multiple clauses with a variety of semantic links that require time to process (Fang & Schleppegrell, 2010). Syntactic anatomy and integration enable students to process their thinking through language, construct better scientific definitions, and utilize skills to cope with the challenging syntax of scientific text (Fang & Schleppegrell, 2010).

Mastering scientific language also presents some daunting challenges for students. In earlier research that is still relevant, Halliday and Martin (1993) conducted an analysis of scientific language that included a discussion of some significant challenges that students face when they do not have a fully developed scientific background (as cited in Sherwood, 2007). These challenges include understanding conjoined definitions, disjoined definitions, interlocking definitions, complex categorizations, special expressions, lengthy passages, multiple interpretations, grammatical metaphors, and gaps in text. Scientific writing is not flexible, and it requires logical arguments, supported claims, outside sources, and proficiency. Student recognition of discipline-specific use of language helps to support their comprehension of how content areas such as science organize knowledge and communicates through reading, writing, evaluating, and modifying text (Fang, 2012).

Success in school requires students to be willing and able to cope with academic language, particularly in the core academic areas. In earlier research, Pella (1976) contended that science instruction has often included an emphasis on using scientific vocabulary to describe the role, place, and content of science (as cited by Bybee, 1997). Many science texts contain numerous vocabulary concepts, present significant amounts of information at once, and are not always successful at transmitting scientific information (Beaver, 2012). Often, textbooks in content areas are above the comprehension levels of students due to advanced text features and unfamiliar vocabulary, even though they are still considered an important learning resource (Beaver, 2012). Vocabulary, as the National Institute of Child Health and Human Development (2000) noted, is the key variable in determining how well students comprehend text (as cited by Kamil & Bernhardt, 2004).

As they progress in their academic careers, students find that the majority of their courses include little or no reading strategy instruction (Weingartner, 2008). This scarcity may be due to the perceptions of teachers about their roles as educators. Some science educators make the assumption that students have learned to read in elementary school, and they are discouraged when students do not understand how to read science text (Weingartner, 2008). Student often do not comprehend text because they lack ability, motivation, or the reading is considered too difficult (Weingartner, 2008).

Metacognitive strategies are designed to help student become aware of their own thought processes and how to modify them to be more effective (Thier, Daviss, & Pratt, 2002). Therefore, instructional models in science should provide (a) guidance for students about how to use different metacognitive strategies, (b) connections between activities, (c) support decision making, and (d) contribute to student development of scientific literacy. It is a common misunderstanding among educators that the opportunity to learn a specific scientific concept can be provided in a single experience or lesson (Bybee, 1997).

Science curriculum is a series of constructed relationships among conceptual schemes, procedural strategies, and contextual factors (Bybee, 1997). Science learning focuses on helping students understand a scientific topic and provides them with a new way of communicating about it (Pappas & Varelas, 2004). Scientific activities involve two connected aspects, which include the process of developing theories and the collecting and analyzing of data (Pappas & Varelas, 2004). Opportunities to improve student engagement in science activities in the classroom should focus on supporting discourse for paraphrasing content as well as on understanding other students' perspectives (Khasnabis, 2008). Science teachers should be able to differentiate between teaching specific skills and knowledge and what it means to do science (Saul, 2004). Science curriculum should provide authentic connections between the concepts and process of science as well as the personal and social elements that students bring to the classroom (Bybee, 1997).

Vocabulary and Science Instruction

A variety of strategies for vocabulary instruction and text comprehension are available to teachers that improve student reading skills. These strategies, according to the National Reading Panel (2000), include explicit and implicit instruction, multimedia methods, capacity methods, and association methods (as cited by Monohan, 2012). Fang

(2010) described five strategies for building student knowledge of scientific vocabulary, including morphemic analysis, vocabulary think charts, concept definition word maps, vocabulary self-collection, and word sorts. A morphemic analysis is the smallest meaningful unit of a term, often associated with prefix, suffix, and root words (Fang & Schleppegrell, 2010). Direct instruction of these word elements can help student develop control of the challenging language of science and improve their understanding of science. Students should develop syntactic and morphological word knowledge through the use of key words and relevant affixes and root terms (Fang & Schleppegrell, 2010). Effective morphemic analysis lessons provide clear explanations with modeling, practice, and authentic application.

Other strategies should also be considered. Vocabulary think charts are designed to encourage student thinking and discussion about specific words and to support their conceptual understanding of those words (Fang & Schleppegrell, 2010). Students can complete this activity as a group or individually after reading a text or summation of a topic to review key concepts. Concept definition word maps provide opportunities for students and teachers to discuss how terms are classified, how to probe the attributes of words, and how to illustrate concepts (Fang & Schleppegrell, 2010). This activity works as a before-reading activity that teachers can use to engage students or assess their prior knowledge of a concept, or it can be used during or after reading activities to help students construct, consolidate, and demonstrate understanding. Vocabulary self-collection also promotes engagement and the learning of specific content vocabulary

(Fang, 2010). This self-collection process consists of reading and selecting terms, defining and explaining these terms, finalizing the word list, and extending the word knowledge with application. Word sorts also help students distinguish common properties among concepts, review and process prior information or assess learning (Fang & Schleppegrell, 2010).

Writing Skills and Science Instruction

In science, students are expected to write logical arguments based on evidence, to use reasoning skills, to participate in the research, and to present their results early in their academic experience (Conley, 2014). Science teachers are expected to improve students' understanding of word meanings, to expand their basic and specialized vocabulary, and to prepare them for the literacy demands of the future. Educators may not be aware that reading and writing in science is significantly different from reading and writing narrative text (Pappas & Varelas, 2004).

Writing to learn is a process that integrates authenticity with information obtained during instruction (Cervetti & Pearson, 2012). The process of writing is a problem solving approach that supports the development of knowledge and communication (Sherwood, 2007). Writing in science is particularly important for upper elementary and middle school student, Keys (1999) noted in earlier research, because this age group is beginning to make connections between scientific learning and content knowledge (as cited by Deal, 2000). When learning about specific content, students must learn to consider the audience and the purpose of each type of writing assignment (Worth et al., 2009).

Previous initiatives encouraged the integration of writing in various content areas, such as science. One such initiative is Writing Across the Curriculum. Several key principles of Writing Across the Curriculum are used to support content learning (Michigan Science Teachers Association, 2014). These principles include writing to promote learning and integrating writing through a diverse student voice and engaging students as critical thinkers. Effective writing instruction integrates all disciplines and provides opportunities to write in every classroom. A writing-to-learn strategy is one which a teacher integrates into a lesson to engage students and to help them develop ideas related to specific science concepts (Michigan Science Teachers Association, 2014). A writing-to-demonstrate knowledge activity is one in which a teacher assigns reports, essays, and other types of writing to support student expression of comprehension and understanding. Writing allows scientists to reflect, communicate, obtain funding, and provide information for the non-expert community. Writing encourages students to connect authentically with science, to clarify and evaluate understanding, to explore ideas, to solve problems and reason, and to improve communication skills. Fang (2010) contended that writing in science promotes conceptual change and therefore enhances learning in science.

Different purposes and audiences, however, call for different types of writing and resources. Science writing involves two purposes: presentational and exploratory (Their et al., 2002). Presentational writing involves recording and presenting relevant details for an audience. This type of writing engages readers, provides guidance to the reading through structure, and utilizes appropriate writing strategies with relevant information (Thier et al., 2002). Exploratory writing is a tool that students use to process learning and meaning. Exploratory writing in science can be done informally as reflections, questions, and conclusions that students record in a science journal. Structured note taking is a transitional metacognitive strategy that connects reading and writing and can include concept mapping or graphic organizers.

Writing in science can be expressed in with both formal and informal approaches. Examples of informal pieces include narrative or creative pieces as well as journals for collecting and organizing ideas. Within the setting of science, a narrative procedure can help provide the step by step process of an investigation that students use to replicate and verify results. Creative writing in science can expand student experiences and skills while strengthening their abilities with language (Thier et al., 2002). The purpose of informal writing is to help students construct understanding and stimulate curiosity. Science journals are an example of how students can use language and visuals to record, organize, and interpret data as well as reflect on their experiences with the scientific process (Fang & Schleppegrell, 2010).

Scientists regularly use both formal and informal types of writing with a variety of audiences and for various purposes within and beyond the scientific community (Fang & Schleppegrell, 2010). One type of writing model educators can utilize includes five dimensions of writing to support scientific learning, including identification of topic, type of genre, purpose, audience, and method of text production (Fang & Schleppegrell, 2010). Science teachers also need to model the process of writing from planning and drafting through composing, revising, and publishing.

Writing is an integral part of what doing and learning science means (Fang & Schleppegrell, 2010). In science writing, the audience and purpose guide the choice of language, writing style, and structure of ideas. An awareness of writing for an audience helps students clarify and deepen their understanding of scientific concepts. Writing genres that can be applied in science include nonfiction narratives, persuasive writing, instructional writing, and formal reports (Fang & Schleppegrell, 2010). Students should utilize their understanding of content knowledge in science to complete tasks such as gathering information, comparing and contrasting scientific beliefs and conventions, creating new conceptual frameworks, evaluating these frameworks, and using metacognitive skills such as goal planning and self-correction (Sherwood, 2007).

In the science classroom, students conduct investigations as well as gather, record, and analyze data. Students use this data to make claims based on evidence, and they synthesize this data to develop a more general understanding of the scientific concepts that they have presented. Science writing, therefore, needs to be taught explicitly and modeled in order for students to experience success (Worth et al., 2009). Students need to review models of various kinds of scientific writing, they need to have access to science texts, they need to discuss their reading material with other students, they need to use content vocabulary accurately, and they need to learn how to use their notebooks as a resource for data, evidence, ideas, and explanations (Worth et al., 2009).

Reading Comprehension Strategies and Science Instruction

No domain presents the academic nature of language better than science, which requires both oral and printed language use as well as symbols to represent concepts (Fang & Schleppegrell, 2010). Teachers of adolescent readers need to support reading for a purpose, build background knowledge, and utilize strategies to better comprehend text in order to be more successful in the learning material (Kim & Anderson, 2011). Reading and writing support conceptual understanding, and they are a key part of the social practices that scientists engage in. When students give personal meaning and purpose to the process of reading, they are better able to comprehend what they read, develop authenticity about the content of the text, and apply the information to their own personal lives (Thier et al., 2002).

Reading comprehension is a strategic process. In earlier research, Cooper (2000) noted that the reader constructs or assigns meaning to text using clues from the text and prior knowledge (as cited by Pratt & Pratt, 2004). Reading comprehension is determined in relation to multiple factors, which include fluency, comprehension strategies, vocabulary knowledge, and text genre (Kamil & Bernhardt, 2004). Comprehension of text includes understanding the purpose of the text and the ability to monitor understanding, determine correct meanings, and summarize the reading material's main ideas (Thier et al., 2002). Comprehension of text requires linguistic knowledge, background knowledge, and the use of a variety of reading strategies (Fang & Schleppegrell, 2010). Reading instruction is best supported and developed within each specific content area since each area varies with how the generate, communicate, evaluate, and examine information. The difficulties of disciplinary text are not just related to vocabulary, but they are also related to the discourse or language patterns in that specific content area (Fang, 2012).

During the process of reading, students should use a variety of strategies to comprehend text, including the use of pencils, highlighters, or sticky notes to identify aspects of the text that are of interest or are confusing (Thier et al., 2002). Graphic organizers provide a visual aid in comprehension, and they are best used as a supplement to learning for students who have developed some comprehension strategies (Thier et al., 2002). The emphasis of reading programs in the primary grades is on decoding text, while reading programs in the upper grades focus on formulaic writing and delivery of information for the ease of assessment (Saul, 2004). Although an emphasis in the primary grades is on reading stories, students need opportunities to read and explore nonfiction, particularly science text (Dreher & Voelker, 2004). During the advanced or disciplinary stages of literacy, students between the ages of 9 and18 must learn to cope with text that emphasizes challenging grammatical metaphor, such as technical, semiotic, and generic abstractions (Fang, 2012). Metaphoric associations are nominalized abstractions derived from process and qualities (Fang, 2012). Specific reading skills build on preliteracy and basic literacy skills prior to this step by supporting language and knowledge skills (Fangs, 2012).

A common assumption with instruction is that teachers across different content areas use similar instructional strategies to help students improve their reading comprehension (Shanahan & Shanahan, 2012). Scientific thinking addresses content and processes of learning and understanding (Krajcik & Sutherland, 2010). Reading science text is a large part of what it is considered to be actively doing science (Norris & Phillips, 2003). Science is one of the most difficult content areas for students to read, Barton et al. (2002) noted, and science educators often feel unprepared to support reading instruction (as cited by Beaver, 2012). Unique skills, Barton et al. (2002) pointed out, such as comprehending text passages, decoding scientific sign and graphics, and understanding different organizational structures in the text are among the challenges that students face in processing science text (as cited by Beaver, 2012). Improving student reading skills helps students understand science content so that they can answer questions on standardized science assessments (Monahan, 2012). School science texts are dense, technical, abstract and complex (Fang & Schleppegrell, 2010). Students need to know if they are improving their use of scientific language. Students should also be expected to demonstrate use of language appropriate to their developmental level (Thier et al., 2002).

The majority of science educators use didactic instructional techniques, such as lecture, to present reading content that students must comprehend (Monohan, 2012). Science educators are less likely to specifically integrate reading instruction, and when they do, Ness (2009) argued, the techniques they use often include question answering, analyzing text, and summarizing (as cited by Monohan, 2012). Many science educators place an emphasis on performance-based activities for doing science rather than reading about science (Kamil & Bernhardt, 2004). In earlier research, Roth (1991)) suggested educators should focus on critical ideas, utilizing questioning, clarifying differences in understanding, implementing activities that support conceptual change, and providing authentic learning experiences (as cited by Deal, 2000).

Instructional reading strategies within a content area are not based on a single method. Educators should consider their curriculum objectives, the needs of their students, and their teaching styles (Beaver, 2012). Factors that influence teacher beliefs and practices about how to integrate reading strategies into science instruction include (a) the utilization of a single curriculum for all students, (b) the demands of content curriculum, (c) time, (d) lack of professional development, and (e) the teacher's own educational background. In addition, teachers need to feel supported in their efforts to improve literacy skills (Weingartner, 2008).

The primary task of science teachers is to help student improve their understanding of scientific concepts and process and to improve their use of scientific language. In previous research, the investment of effort and time to improve scientific language skills has a positive influence on the academic progress of the students (Thier et al., 2002). Instructional approaches that support literacy and science integration include establishing clear performance expectations, emphasizing metacognitive skills, and applying strategies for directing student attention towards specific learning in the structured educational environment of the classroom (Thier et al., 2002). Effective instruction related to scientific language requires teachers to use specific learning strategies, to explain and demonstrate them, and to guide and coach students as they utilize these skills to learn science. The ability to use and understand scientific language is necessary to practice good science. The more effective students are able to apply scientific language, the easier and more satisfying instruction becomes. Prereading, reading, and after-reading strategies should be utilized by content teachers to support student development as independent and engaged readings of informational text such as those in science (Johnson & Mongo, 2008).

According to the 2013 National Assessment of Educational Progress (NAEP) reading assessments, 26% of eighth graders perform below the basic level of reading, which means they are unable to demonstrate an understanding of what they read. Poor academic performance across content areas can be directly linked to lack of reading comprehension skills (Kim & Anderson, 2011). This finding supports the need to emphasize literacy skills in all content areas, including science, in order for students to develop new skills and strategies (Fang & Schleppegrell, 2010). Students must be able to learn metacognitive strategies to read for purpose and to determine ideas within the reading. By asking students to identify and record key concepts, words, and passages in reading material, teachers provide them with direction and purpose so that they are actively engaged in the reading process (Thier et al., 2002). Understanding of informational text depends on the kinds of questions that teachers and students ask. Open-ended questions expand students' comprehension and invite a variety of perspectives.

Teachers who understand how scientific meaning is constructed are better able to anticipate and address the challenges that students face in relation to reading assignments in science (Fang & Schleppegrell, 2010). To help students become better readers in science, teachers must provide opportunities for reading, provide the tools for coping with the demands of scientific language, and scaffold their interaction with text through the use of specific reading strategies (Fang & Schleppegrell, 2010). Scientific literacy also requires students to use interpretive strategies to process science text (Norris & Phillips, 2003). Content specific statements, such as those in science, transform the dynamic processes of the natural world into abstract ideas (Gee, 2004). The goal of scientific literacy is to conceptualize content so that student readers are not overwhelmed. Firsthand experience in science can be enhanced with text and language to encourage conceptual understanding of science as well as to benefit literacy development (Cervetti & Pearson, 2012). Without the written word in science, it would be impossible to record and present data, preserve information, conduct peer reviews, re-examine information, connect ideas, or communicate concepts. Reading in science is a fundamental aspect of scientific literacy (Norris & Phillips, 2003).

Scientifically literate students, Holliday, Yore, and Alvermann (1994) contended, must be able to evaluate text, communicate their ideas, and discuss the impact their own ideas within science (as cited by Weingartner, 2008). Civic scientific literacy involves a vocabulary dimension as well as an inquiry dimension (Bybee, 1997). In relation to the vocabulary dimension, successful reading leads to knowledge of the meaning of individual terms and an assumption that scientific constructs are required to understand scientific text. The essential nature of reading, which involves interpreting meaning from text, is the same, no matter the material read (Norris & Phillips, 2003). In order to support scientific literacy, students must be able to use reading and writing skills effectively to understand and communicate scientific concepts (Weingartner, 2008).

Students must become familiar with the purpose, text structure, and grammatical features of different types of scientific text (Fang & Schleppegrell, 2010). Teaching different types of scientific text requires orientation, modeling, and guided and independent text construction. One way that science teachers can expand students' content knowledge in science and support inquiry learning is to utilize a variety of science related reading texts. Students need to be trained in the process of reading scientific materials, because students need to understand text structure specific to science in order to construct and communicate information (Fang & Schleppegrell, 2010). Understanding logical reasoning in science is another skill that is necessary for successful comprehension of science text. The texts of science classes tend to have highly specialized topics that are often removed from the everyday life experiences of the students (Fang, 2012). Science text often integrates visual information, graphical diagrams, and mathematical information associated with verbal text (Fang, 2012).

Trade books in science often provide examples of how scientists generate questions by providing written models of the scientific process (Fang & Schleppegrell, 2010). These trade books also provide opportunities to engage students' interest in science. Trade books also offer more options to accommodate the variety of student reading abilities, and as a result, students are more likely to engage in science learning. In addition, these trade books often promote inquiry learning and support critical thinking skills. Trade books also support such skills as finding information about the author, examining the table of contents and other book structure features, interpreting diagrams and images, and utilizing cited sources to verify information. Exploring the lives of scientists supports students' appreciation for science, makes science instruction more manageable for teachers, and attracts students to scientific careers (Fang & Schleppegrell, 2010).

Science teachers also need to emphasize a variety of reading skills that range from the basic to the advanced level within their content area (Ediger, 2009). Reading instruction within content areas should focus on skills such as word recognition, comprehension of ideas, structural analysis, syntax, and problem solving. An instructional strategy that science teachers can use to improve reading comprehension and word recognition skills is utilizing text that enhances student interests and readability levels (Ediger, 2009). Following a reading experience, science teachers should discuss the content with students by asking challenging questions. Read a-louds also provide teachers with opportunities to model how to read science text. The science teacher models expressive reading, scientific thinking skills, and problem solving throughout the text (Fang & Schleppegrell, 2010). Reading is a complex process that requires students to use various strategies for integrating prior knowledge, developing comprehension, and recalling information. Types of strategies found to improve reading of expository text in science include prior knowledge, comprehension monitoring, and organization of text information for recall and review (Fang & Schleppegrell, 2010).

Science teachers need to develop a repertoire of reading strategies that they can use in the science classroom to improve student understanding of scientific material. Prior knowledge is one of the most important strategies that teachers can use to improve student comprehension (Fang & Schleppegrell, 2010). It is necessary to draw on the background of students, because their prior knowledge and ability make the reading experience authentic (Johnson & Mongo, 2008). Teachers can also use strategies such as anticipation guides, Know-Want-Learn (KWL) charts, prior knowledge, and monitoring and integrating charts to improve comprehension (Fang & Schleppegrell, 2010). During reading, teachers can help students think about what they are reading by using such strategies as think-pair-share, questioning the author, and reciprocal teaching. Strategies that support student organization of text information for review, recall, and study include graphic organizers, Survey-Question-Read-Recite-Review charts, and two-column note taking (Fang & Schleppegrell, 2010).

The development of reading skills in science can be supported through a different instructional approaches and strategies. Krajick (2010) suggested five instructional and curricular aspects that support the improvement of reading skills in science: (a) linking new ideas to prior knowledge, (b) connecting learning meaningfully to students, (c) utilizing multiple representations, (d) provide opportunities for students to use scientific ideas, and supporting student engagement with scientific discourse. Learning logs are an informal tool that teachers can use to document student learning beyond the classroom, such as their understanding of scientific phenomena, the questions they raise, the inferences and explanations they make, and the connections they make (Fang & Schleppegrell, 2010). Educators can encourage vocabulary development by helping them utilize new terms through engaging activities, word origins, as well as speaking, listening, reading, and writing use (Blintz, 2011).

In a science classroom, teachers should encourage students to talk about their experiences in order to help them make connections, clarify thoughts, form conclusions, and develop theories and questions in relation to their science reading (Worth et al., 2009). Discourse for students is focused on presenting information in an effective way for a specific audience. Supporting student engagement in science conversation supports their reading comprehension skills as well (Worth et al., 2009). Another strategy to improve reading comprehension is the use of questioning techniques in inquiry-based instruction. Science teachers often use questions with an emphasis on the right answer rather than asking students to make sense of the science content (Pasley et al., 2004). Teachers who use inquiry-based education, however, use strategies that improve reading comprehension in science, including question asking and problem identification, the use of models, an investigative process, analysis of data, higher order thinking skills, an emphasis on explanations and solutions, and evaluation of information (Stage et al., 2013).

Concerning informational text, science teachers often focus on basic skills such as decoding, fluency, and summarizing, but provide little focus on the specific language demands presented in these types of text (Fang & Schleppegrell, 2010). It is important that students read other types of text when exploring science content, including trade books, science journals, and magazines. These texts provide authentic exposure to academic language in science. Lack of experience with expository text can have a serious negative effect on the development of literacy skills for students (Fang & Schleppegrell, 2010).

Literacy Interventions and Science Instruction

Intervention research supports the idea that reading instruction should be integrated into the content areas, such as science (Zygouris-Coe, 2012). In earlier research, Pappas and Varelas (2004) contended that effective units of instruction that include both literacy and science skills have five major components. These components include hands on exploration and discussion, read-aloud sessions, writing and drawing experiences, small group literature circles, and at home exploration activities or reading assignments. Monahan (2012) described a reading intervention, the Quality English and Science Teaching (QuEST), that the Center for Research on Educational Achievement and Teaching of English Language Learners developed to support improvement in both science and academic language for middle school students in mainstream classrooms, and they found that all students improved in both science and literacy skills. Romance and Vitale (2011) described another intervention program, known as Science IDEAS, as a cognitive science-oriented model that utilizes both reading and writing in conjunction with science instruction. Romance and Vitale found that this intervention had a positive effect on student achievement. However, James-Burdumy et al. (2009) found that many different reading interventions, such as Project CRISS, ReadABout, Read for Real, and Reading for Knowledge did not have a significant effect on reading comprehension in students (as cited by Monohan, 2012).

Interventions focused on language and science in content rich literacy environments, Morrow et al. (1997) noted, have been found to be effective (as cited by Kamil & Bernhardt, 2004). These interventions included guided literacy activities, teacher guided activities for writing narratives, and student directed periods of reading and writing in a social setting. One limitation of the study conducted by Kamil and Bernhardt (2004), however, is that no hands-on scientific experiences were included. Empirical research also provides a significant amount of evidence that suggests a language and literacy emphasis in science interventions improves student engagement and scientific learning (Fang & Schleppegrell, 2010). A recent trend in science education reform has been the use of language and literacy skills in intense interventions to improve student learning (Fang & Schleppegrell, 2010).

Evaluation of Reading and Science Instruction

Evaluation of reading and science instruction has revealed limited evidence about improved student performance on science assessments or on student engagement in science activities. In earlier research, Shavelson, Baxter, and Pine (1992) found no relationship between reading science material and performance assessments in science (as cited in Kamil & Bernhardt, 2004). In a study on developing understanding in science across the lifespan, Hahn et al. (2013) found that the scientific literacy skills of kindergarten students correlated with their interest in science, music, art, and reading. However, for other grades, this correlation was not observed. For students in Grade 6, Hahn et al. found no significant correlation between scientific literacy and engagement in science activities. For students in Grade 9, Hahn et al. found a low correlation between scientific literacy and engagement in science.

In other research, students' abilities to demonstrate scientific knowledge on assessments did not correlate with their abilities to obtain scientific knowledge from a text. Monahan (2012) found that the assessment results of students in reading are directly related to their assessment results in science. No formal assessment has been developed to measure authentic improvements in science learning as the result of literacy skills instruction in the science classroom (Monahan, 2012). Educators, however, still believe that literacy skills instruction in the science classroom is helpful, even though no evidence has emerged to support this idea (Thier, Daviss, & Pratt, 2002).

Challenges of Integrating Literacy Skills into Science Instruction

The major challenge that science educators face is to integrate literacy skills into science instruction in order to support the goal of developing scientific literacy for all students (Pratt & Pratt, 2004). The focus on linking literacy and science skills, however, will not save time or make instruction more efficient. To replace science vocabulary lessons with inquiry and exploration activities in science undermines both vocabulary and science instruction (Saul, 2004). Science educators need to move beyond a focus on content memorization to a deeper understanding of the role of literacy in making new connections (Worth et al., 2009). Instructional concerns include avoiding a focus on decoding and defining vocabulary and focusing on phonic or language development rather than content.

Other challenges were also revealed in the research literature. Science educators face the challenge of understanding that a lack of reading skills and writing skills is related to a lack of knowledge about science (Worth et al., 2009). Another challenge with literacy skill integration is that science teachers often do not implement literacy strategies properly (Fensham, 2011). The practice of science is not about reading and remembering information presented in the textbook, but rather it is about experiences with the natural and designed world and about explanations obtained in relation to questions about these aspects (Fensham, 2011). In addition, teacher use of these strategies has not been shown to improve adolescents' literacy skills (Beaver, 2012). Little is also known about how teachers use literacy skills in the daily activities of science classrooms, and therefore, additional studies are necessary to target literacy integration into science learning (Beaver, 2012). Another challenge is that educators often assume that secondary school students already know how to read and comprehend text, which has contributed to a lack of literacy instruction beyond Grade 3 (Zygouris-Coe, 2012). However, elementary school teachers often have limited experience with science content (Thier et al., 2002). Secondary science educators also do not include specific literacy pedagogy as part of their instruction, despite acknowledgement that it is needed (Monahan, 2012). Many science teachers do not feel equipped to teach language related skills. Therefore, science teachers need significant professional development in order to be more effective instructors (Thier et al., 2002).

Summary and Conclusions

This chapter included a review of the literature. In this chapter, I discussed the literature review strategies that I used to conduct this search and the theoretical framework that I used to support this study. In addition, I reviewed research on rural education, and the Common Core State Standards in English Language Arts (ELA) in relation to science instruction. I also reviewed research related to scientific literacy, including the history of scientific literacy, the need for scientific literacy in American society, the goals for achieving scientific literacy, and the development and assessment of scientific literacy in K-12 education. In addition, I reviewed science instruction in relation to vocabulary development, instructional strategies in writing and reading, and the challenges of integrating literacy skills into science instruction.

Several themes emerged from this literature review. The first theme is that science instruction in rural education environments must take into consideration the community and its available resources. In order to support the development of science knowledge, the rural community must understand that scientific literacy is necessary for all citizens. Scientific literacy is the ability to understand the process and purpose of science. An understanding of the natural world through science helps to support problem solving and informed decision making. The framework of scientific literacy introduced by Bybee (1997) provides a structural approach for aligning and assessing science curriculum towards the development of scientific literacy rather than the traditional approach of memorizing facts. Literacy instruction supports scientific literacy by requiring students to evaluate text, communicate their ideas, and support their perspectives with evidence. Therefore, rural educators and their community need to support the integration of literacy skills instruction into the content area of science.

Another theme that emerged from this literature review is that implementation of the Common Core ELA State Standards may be an effective way to integrate literacy skills instruction into the content area of science. Lee, Quinn, and Valdes (2013) suggested that educators who focus on supporting the development of students' English language arts skills in science will have a positive impact on their development of scientific knowledge. Alignment to the Common Core ELA State Standards requires educators to prepare students to read and understand informational text. These standards also expect that students will be able to develop and present logical arguments based on evidence, which is vital in becoming scientifically literate. The Common Core ELA State Standards provide an opportunity for students to integrate literacy skills into their authentic learning experiences in science.

An additional theme that emerged from this literature review is a need to modify instruction of science away from direct instruction and the memorization of facts and towards developing an understanding of the nature of science. The traditional approach to science education focuses on the memorization of facts rather than on scientific understanding. Teachers who effectively integrate literacy skills into science instruction provide opportunities for students to process evidence, express and communicate their understanding of scientific concepts, and make better decisions in relation to the natural world. In comparison to elementary school education, secondary school education includes less direct literacy instruction within content area courses such as science. Because of the challenging text and vocabulary in the content area of science, science educators need to support the integration of literacy skills instruction, guided by the Common Core ELA State Standards, into the content area of science.

Several conclusions can be determined from a review of the research presented in this chapter. Teachers can use interdisciplinary approaches to support the development of scientific literacy by relating to students' existing interests and knowledge within the sciences (Ross, Hooten, & Cohen, 2013). Another conclusion is that the language of the science classroom plays a significant part in the fields of science and engineering, and therefore, strong reading and writing skills are needed to achieve scientific literacy in these fields (Lee, Quinn, & Valdes, 2013). Another conclusion drawn from this research is that educators need to engage in the process of providing leadership, influencing curriculum, and developing instructional materials that address the specific goals of science literacy (DeBoer, 2000). Research shows most secondary teachers have difficulty understanding what it means to be a reader or a writer in specific content areas (NCTE, 2011). Science educators may not have had enough opportunity to consider what it means to be a reader or writer in their content area. When students do not have strategies for reading science text and opportunities to write about science, students have difficultly mastering the concepts of the course (NCTE, 2011). Therefore, students in a science classroom must read, write, observe, and develop visual representations at the same time that they develop models and explanations (Lee et al., 2013). Language use in the science classroom should focus more on the language that students use in communication and learning rather than on the structure of language in relation to phonology, morphology, vocabulary, and syntax. These activities provide opportunities and demands for language learning as well as promoting the process of learning science and can include all students, regardless of their language experiences. The focus of science instruction should be on making meaning and on contributing and communicating ideas in order to develop a common understanding for the process of science language learning (Lee et al., 2013).

A review of the research literature for this study revealed several research gaps. A gap in research exists about the impact of integrating the Common Core ELA State

Standards into science instruction on the scientific literacy skills of students. Researchers hope that a focus on literacy instruction in all content areas through implementation of the Common Core State Standards will result in an improvement in students' reading and writing skills, but more research is needed (Conley, 2011; Guthrie et al., 2004; Lee et al., 2013;). Educators must improve students' reading comprehension skills in order to build understanding in science (Fang, 2010). Researchers have also expressed concern that an emphasis on reading instruction in science could have a negative impact on students' understanding of science content knowledge (Fang, 2010). This study addresses this research gap by determining if there is a significant relationship between scientific literacy skills of students in a rural middle school and science instruction that is aligned to the Common Core ELA State Standards in an intensive science intervention during summer school.

The research literature supports the research design of this study, which is described in Chapter 3. In this chapter, I present the research method and rationale as well as the protocols that I planned to follow for data collection and analysis. I also discuss specific strategies that I planned to use to improve the validity and reliability of this study.

Chapter 3: Research Method

The purpose of this study was to determine relationship between the alignment of curriculum and instruction in the content area of science to the Common Core ELA State Standards and the scientific literacy of middle school students. The results of this study provide insights into the relationship between the alignment of science curriculum and instruction to the Common Core ELA State Standards and the scientific literacy levels of students receiving the alignment. Research issues associated with this study include the challenges of rural education, student achievement of scientific literacy, and the integration of the Common Core ELA State Standards into science curriculum and instruction.

This chapter includes a description of the quantitative research method that I used to analyze how the integration of the Common Core ELA Standards into science instruction correlates with scientific literacy during an intensive intervention at a rural middle school. This chapter also includes a description of the quantitative research design and rationale, the research questions, setting, target population and sampling, procedures for recruitment and participation and data collection, instrumentation, the data analysis plan, a discussion of threats to validity, and ethical considerations.

Research Design and Rationale

In this quantitative study, I used a quasi-experimental design. Quasi-experiments are similar to experimental designs in that variables are examined within a population sample, but random assignment is not possible (Shadish, Cook, & Campbell, 2002). The group of students for this study was not randomly selected, but was dependent on the voluntary participation of the students. The quasi-experimental design best suited for this sampling scenario was the one-group pretest-posttest design that Shadish et al. (2002) presented.

The pretest-posttest control group design was selected for this study to determine the relationship between the alignment of the Common Core ELA State Standards with science curriculum and instruction and the scientific literacy skills of middle school students. The variables of this study were the integration of the Common Core ELA Standards, which was the single independent variable, and the scientific literacy skills of students, which was the dependent variable. Scientific literacy was measured using the released scientific literacy test items from the 2011 TIMSS as aligned to Bybee's (1997) theoretical scale of scientific literacy. Students completed a pre and posttest containing assessment items from the 2011 TIMSS that are related to scientific literacy. This research design includes randomized groups to control for the internal validity (Campbell & Stanley, 1963). This design includes a test group and a control group with the introduction of a treatment for the test group in order to compare the two groups. The test group were students who participated in a summer school experience that included an intensive science intervention aligned to the Common Core ELA State Standards, and the control group were students who did not participate in the summer school experience.

The research design was a pre and posttest analysis to determine the relationship between the alignment of the Common Core ELA State Standards with curriculum and instruction in science and the scientific literacy skills of these students. The pre and posttests were given to both groups of students. This alignment and integration was analyzed using ANOVA for descriptive categories that influence the pre and posttests. ANOVA was also used to determine the impact of the intensive science intervention on the scientific literacy skills of each student. At the beginning of the statistical analysis of the interval data, a normality test was used to determine that the data fit within a normal distribution. Descriptive statistics were also generated, including, mean, standard deviation, variance, standard error of the mean, median, mode, and range. The use of ANOVA within each type of measurement allowed for an examination of the effect of the intensive intervention, which was the intensive science intervention. Students were given a pre and posttest containing 2011 TIMSS scientific literacy assessment items used for this study, which included concepts related to biology, chemistry, and physics.

The following research questions and hypotheses were developed in relation to the research design and the theoretical framework of this study.

RQ1: What is the relationship between the Common Core ELA State Standards and scientific literacy?

$H_0$1: There is no significant relationship between the Common Core ELA State Standards and scientific literacy.

$H_1$1: There is a significant relationship between the Common Core ELA State Standards and scientific literacy.

RQ2: What is the relationship between an intensive science intervention and scientific literacy?

$H_0$2: There is no significant relationship between an intensive science intervention and scientific literacy.

$H_1$2 There is a significant relationship between an intensive science intervention and scientific literacy.

RQ3: Does teacher integration of the Common Core ELA State Standards into an intensive intervention affect scientific literacy?

$H_1$3: Teacher integration of the Common Core ELA State Standards into an intensive intervention does not have an effect on scientific literacy.

$H_1$3: Teacher integration of the Common Core ELA State Standards into an intensive intervention has an effect on scientific literacy.

In the first research, I question addressed the relationship between the Common Core ELA State Standards and scientific literacy in order to determine if there was a relationship between science teachers' use of these standards and the scientific literacy skills of students in a rural middle school. Data were examined using ANOVA and a Likert scale of teacher-determined levels of alignment with the Common Core ELA State Standards. In the second and third research questions, I addressed the relationship between the intensive summer school intervention in science and the scientific literacy skills of these middle school students. These data were also examined using ANOVA.

This study was designed to determine if the alignment and integration of the Common Core ELA State Standards into science curriculum and instruction during an intensive summer school intervention improved scientific literacy for rural middle school students. The teachers in this study used a Likert scale to determine their level of instructional alignment in relation to the Common Core ELA State Standards. A score of 1 represents low alignment to the Common Core ELA State Standards while a score of 5 represents a high alignment with these standards. The focus of this study was on the integration of the Common Core ELA State Standards and the level of teacher alignment to these standards, which was the independent variable, and the scientific literacy of middle school students, which was the dependent variable. Scientific literacy was measured using released scientific literacy test items from the 2011 TIMSS.

Setting

The educational setting for this study was a rural middle school located in a farming community in Southern Arizona. For 2013-2014, this school enrolled 123 students (National Center for Educational Statistics, 2014). This school had a population of 52% Caucasians, 46% Hispanics, and 1% Native Americans. English as a second language (ESL) students comprised 25% of the student population. This school qualified as a Title 1 school, with 80% of students' home incomes qualifying them for the free or reduced lunch program.

Target Population

The target population was students enrolled in Grades 5, 6, 7, or 8 for the 2014-2015 school year, some of whom were involved in an intensive science intervention during a summer school experience in 2015. These students lived in a rural location and may not have had access to extracurricular activities, such as a summer school experience. The student middle school population was expected to be adequately represented in this summer school experience, considering the small number of students who attended the school and considering the number of students who were involved in the 2014 experience, which was a total of 15 students. It was expected that the results of this study would be applicable to other rural schools with comparable student populations and demographics.

Sampling and Sampling Procedures

The sampling strategy for this study was based on middle school students' voluntary participation in an intensive science intervention during summer school. This sampling strategy was created by soliciting all middle school students who completed Grades 5, 6, 7, or 8 during the 2014-2015 school year, which represents the nonprobability sample design of convenience sampling. This study used a quasi-experimental research design because the group of students was not randomly selected and because the study was dependent on the voluntary participation of the students. Convenience sampling was utilized for this study due to the willingness of the teachers at the research site to integrate the Common Core ELA State Standards into their science instruction and their willingness to work with the researcher.

The research design best suited for this sampling scenario was the one-group pretest-posttest design that Shadish, Cook, and Campbell (2002) presented. The sample size of the group was expected to be a significant portion of the population of the school. Students who participated in the summer school intervention served as the experimental group. Students who did not participate in the summer school intervention served as the control group.

Sample size was determined by considering the statistical test for this analysis, effect size, alpha values, and statistical power. With a medium effect size equal to 0.5, an alpha value of 0.05 and a power of 80%, the recommended sample size was 12 for this study as calculated using G*Power 3.1 (Faul, Erdfelder, Lang, & Buchner, 2007). This sample size was determined using F tests test families and ANOVA with repeated measure within-between interaction through G*Power 3.1. The sample size of the group was expected to be about 19% of the total population of the school, based on 2014 summer school participation.

Procedures for Recruitment, Participation, and Data Collection

Concerning recruitment procedures, I first obtained a letter of cooperation from the research partner for this study, which was the school district in which the middle school research site was located. I asked the principal of the middle school, who was also the superintendent of the district, to sign a letter of cooperation (see Appendix) indicating the district's willingness to be my research partner. In addition, I asked this individual to sign a data use agreement form, giving me permission to collect student assessment data related to this study (see Appendix). Participants in the study were recruited by the school from the population of middle school students who formed the experimental group and the control group.

In relation to data collection procedures, I obtained student data, including scores on the 2011 TIMSS scientific literacy assessment items for students who participated in the science intervention during summer school. This information was reported anonymously, because each student was assigned a random number and their demographic information and assessments score was documented with this number. The teacher who provided instruction for this intensive intervention recorded this information using the random number assignment. The principal of the school selected the teacher who conducted the summer school intervention in science. Students discussed their experiences in the science intervention, and the teacher discussed this student feedback with me. In addition, students completed anonymous feedback forms on their reflections about their summer school experience.

Instrumentation

The 2011 TIMSS released items comprised the scientific literacy instrument that I used for this study. The released items were free for individuals to use for research and educational purposes. The TIMSS has been used by educators since 1995 to track the achievement of students in mathematics and science in the United States against the achievement of students in other countries (Boyer, 2006). The TIMSS ensures reliability through the review of various science coordinators and consultants, the Science and Mathematics Item Review Committee (SMIRC), and the National Research Coordinators (Mullis & Martin, 2011). Each submitted test item is field tested a year or more before becoming a part of the TIMSS assessment process in order to ensure validity of the assessment items (Mullis & Martin, 2011).

Bybee's (1997) theoretical scale for scientific literacy aligns with the benchmark scores of the 2011 TIMSS, which is based on a framework that addresses scientific content in science as well as the thinking processes associated with engagement in science (Martin, Mullis, Foy, & Stanco, 2012). The highest level of Bybee's scale for scientific literacy is multidimensional scientific literacy, which is observed when individuals integrate scientific understanding into the philosophy, history, and social aspects of science. Individuals who display multidimensional scientific literacy express appreciation for science, an understanding for how science applies to their daily lives, and how various contexts apply in different scientific disciplines (Bybee, 1997). Multi-dimensional scientific literacy can be assessed on the 2011 TIMSS with benchmark scores of 62.5% or higher. Advanced benchmark scores illustrate the ability to communicate and understand complex and abstract concepts in biology, chemistry, physics and earth science (Martin, Mullis, Foy, & Stanco, 2012).

The next level in Bybee's (1997) framework for scientific literacy, conceptual scientific literacy, is present when individuals display some understanding of major scientific concepts and ideas, including the scientific process and design. Conceptual scientific literacy is represented on the 2011 TIMSS with benchmark scores between 55% and 62.49%. High benchmark scores on the 2011 TIMSS 2011 demonstrate an understanding of concepts related to science cycles, systems, and principles (Martin, Mullis, Foy, & Stanco, 2012).

The third level of Bybee's (1997) framework is functional scientific literacy. Functional scientific literacy is observed when individuals describe a scientific concept, but they have a limited understanding of it. Functional scientific literacy is represented on the 2011 TIMSS with a benchmark scores between 47.5% and 54.99%. Intermediate benchmark scores on the 2011 TIMSS indicate an ability to apply an understanding of basic scientific knowledge in different contexts (Martin, Mullis, Foy, & Stanco, 2012).

The fourth level, nominal scientific literacy, is present when individuals relate information as scientific, but their understanding includes misconceptions (Bybee, 1997). Nominal scientific literacy is represented on the 2011 TIMSS 2011 with benchmark scores between 40% and 47.49%. Low benchmark scores on the 2011 TIMSS 2011 is identified by an ability to recognize basics facts from life and physical science (Martin, Mullis, Foy, & Stanco, 2012). Finally, the lowest level of scientific literacy is scientific illiteracy, which refers to individuals who are unable to relate or respond to scientific inquires (Bybee, 1997). These individuals lack the vocabulary, contexts, or cognitive ability to process scientifically. Scientific illiteracy is represented on the 2011 TIMSS with a benchmark score of less than 40%.

Data Analysis Plan

For this study, I used the Statistical Package for the Social Science (SPSS) to process research data and provide statistical analysis (IBM, 2013). I compared the Likert scale of teacher determined levels of alignment with the Common Core ELA State Standards to students' scientific literacy scores from the 2011 TIMSS. At the beginning of this statistical analysis, I used a normality test to determine that the data fits within a normal distribution. SPSS was also used to generate descriptive statistics, including number, mean, standard deviation, variance, standard error of the mean, median, mode, and range. The use of ANOVA allowed for the examination of the effect of the treatment, which was the integration of the Common Core ELA State Standards into science curriculum and instruction, on the dependent variable, which was the scientific literacy skills of the students, as well as teacher perceptions of the alignment of the science curriculum and instruction to the Common Core ELA State Standards. Students also completed a pre and posttest containing the TIMSS assessment items related to scientific literacy, as well as three smaller, specific science concept tests in biology, chemistry, and physics, supporting repeated-measures design.

The purpose of this study this study, as reflected in the research questions, was to examine the relationship between the alignment of the Common Core ELA State Standards with science curriculum and instruction and the scientific literacy skills of middle school students. The null hypothesis for this question was that there is no significant relationship between the Common Core ELA State Standards and the scientific literacy skills of middle school students, while the alternative hypothesis was that there was a significant relationship between the Common Core ELA State Standards and the scientific literacy skills of middle school students. It was expected that if TIMSS 2011 assessment scores are predictive of scientific literacy scores as compared to teacher perceptions of their integration of the Common Core ELA State Standards into science curriculum and instruction, this integration will improve scientific literacy skills for middle school students.

Threats to Validity

One of the threats to validity was the non-random nature of the sample. The experimental group included students who elected to participate in the summer school intervention. Though all middle school students were invited to participate in this study, only students who chose to attend the summer school experience in science were included in this sampling. A fully experimental study would require randomly assigning an instructor and student population, which was not possible due to the rural location and population size of the school. The sample size was small, given the location and population of the rural school. The number of students, though small, represented the majority of students who attended the rural school. Due to the small population of the school, the middle school principal selected only one science teacher to participate in the summer school science intervention.

The process of how the summer school teacher chose to integrate the Common Core ELA State Standards into science curriculum and instruction for the intensive science intervention may have affected the efficacy of the intervention. District and/or school educators may have used additional interventions to improve student achievement in science prior to this study. It was not possible to assign causation to the treatment, given the quasi-experimental design of the study. The issue of pre-assessment effect, concerning how students performs on a pre-assessment, also needed to be considered, because students had limited opportunities to improve their scientific literacy skills, a fact which could have threatened the external validity of this study.

Ethical concerns for this quantitative study include issues related to recruitment and data collection. In relation to recruitment, I developed an invitation flyer that I distributed to all middle school students and their parents a month prior to the start of the summer school and then again prior to the end of the school year. In relation to data collection, I asked the teacher who provided the summer school science intervention to students to remove all identifiable information before submitting any student data to me. I assigned random numbers to students' pre and posttest results to ensure confidentiality and to prevent bias in the analysis and interpretation of results.

Summary

This chapter included a description of the research method for this quantitative study, which will use a quasi-experimental design. The main purpose of this study was to determine the relationship between the integration of the Common Core ELA State Standards into science curriculum and instruction and the scientific literacy skills of middle school students. All teachers at this middle school were expected to align their curriculum with the state standards, which included the integration of the recently adopted Common Core ELA State Standards into science instruction. The independent variable for this study was the alignment and integration of the Common Core ELA State Standards into science curriculum and instruction, and the dependent variable was the scientific literacy skills of middle school students. For this quasi-experimental group, an experimental group and a control group were determined. An intensive intervention in science into which the teacher integrated the Common Core ELA Standards was the treatment for the experimental group. Scientific literacy for both groups was measured using released scientific literacy test items from the 2011 TIMSS, which was aligned with the framework of Bybee’s (1997) theoretical scale of scientific literacy. The statistical test that I used for this study was ANOVA in order to analyze the variations that occurred between the teacher’s perceptions about the alignment of the Common Core ELA State Standards to each science lesson, as measured on a Likert scale, and the students’ performance on the 2011 TIMSS scientific literacy items. Results of the statistical analysis, which are presented in Chapter 4, may illustrate how integration of the Common Core ELA State Standards into science curriculum influences science instruction, which is outside the traditional environment of literacy instruction, and the scientific literacy skills of students.

Chapter 4: Results

The purpose of this study was to determine the relationship between the alignment of curriculum and instruction in the content area of science to the Common Core ELA State Standards and the scientific literacy of middle school students. In this quantitative study, I used a quasi-experimental design. The pretest-posttest control group design was selected for this study to determine the relationship between the alignment of the Common Core ELA State Standards with science curriculum and instruction and the scientific literacy skills of middle school students. The experimental group included students who participated in a summer school experience that was an intensive science intervention aligned to the Common Core ELA State Standards, and the control group were students who did not participate in the summer school experience. The variables of this study were the integration of the Common Core ELA Standards, which was the single independent variable, and the scientific literacy skills of students, which was the dependent variable. The research questions and hypotheses that were used for this research design and the theoretical framework of this study included the following:

RQ1: What is the relationship between the Common Core ELA State Standards and scientific literacy?

$H_0$1: There is no significant relationship between the Common Core ELA State Standards and scientific literacy.

$H_1$1: There is a significant relationship between the Common Core ELA State Standards and scientific literacy.

RQ2: What is the relationship between an intensive science intervention and scientific literacy?

*H_0*2: There is no significant relationship between an intensive science intervention and scientific literacy.

*H_1*2: There is a significant relationship between an intensive science intervention and scientific literacy.

RQ3: Does teacher integration of the Common Core ELA State Standards into an intensive intervention affect scientific literacy?

*H_1*3: Teacher integration of the Common Core ELA State Standards into an intensive intervention does not have an effect on scientific literacy.

*H_1*3: Teacher integration of the Common Core ELA State Standards into an intensive intervention has an effect on scientific literacy.

This chapter includes the results of this study, including an analysis of the integration of Common Core ELA Standards into science instruction to determine a correlation was present with scientific literacy during an intensive intervention at a rural middle school. This chapter also includes the data collection process, description of the treatment, a report of the statistical results and their assumptions, the results, and a summary.

Data Collection

Data were collected during the months of May, 2015 and June, 2015, using items from the pre and posttest assessments that were released from the 2011 TIMSS that addressed concepts related to biology, chemistry, and physics. The personnel of the school district personnel provided access to data. Participants' scores on the 2011 TIMSS items were provided, using random sampling number assignment. To guarantee the protection of privacy, scores had no identification information except for the random sample number assignment. Data were obtained with permission from the superintendent and principal of the participating school and district, using the data use agreement form (Appendix).

Treatment

The lead teacher for the summer school experience was a teacher who had just completed her first year of teaching at the middle school science at the rural school. This teacher was responsible for providing science instruction to students in Grades 5 through 8 during the 2014-2015 and 2015-2016 school years. All middle school students who would be entering Grades 5 through 8 in the 2015-2016 school year were to participate in the science summer school experience, and as a result, a total of 15 students were assessed using a pretest during the month of May, 2015. This number represented a total of 13.39% of the total school population based on 112 students enrolled during the 2014-2015 school year (National Center for Educational Statistics, 2014). The students were given 4 hours to complete the pretest. A total of 10 students started the summer school experience, and seven students completed the experience. This number represented 6.25% of the total school population for the 2014-2015 school year. The original target sample size was 12 participants, which may have been reached to the length of the summer school. The previous summer school experience at this rural school was 2 weeks in length, and this year, the summer school was extended to 4 weeks. Unlike previous years, transportation was provided by the school to encourage attendance.

The science curriculum that the teacher used included chapters from the Biological Science Curriculum Study (BSCS, 2012) preview curriculum for middle school science. The units included electricity, heat energy, and scientific literacy. This curriculum integrated the 5E instructional model approach, which breaks each unit into sections: engage, explore, explain, elaborate, and explain (BSCS, 2015). Each unit began with an engage activity that introduces the topic. The explore activity is where the students conducts observations based on the material. The explain activity includes a discussion of the unit and uses organization skills and multimedia activities to support the material. The elaborate activity occurs when students conduct additional observations related to the topic. The unit is completed with an evaluate activity in which the students must use their knowledge to address a challenge. The BSCS curriculum also includes metacognitive and literacy strategies as part of the curriculum, and an emphasis is placed on collaborative learning (BSCS, 2012). The science teacher used the BSCS curriculum for approximately 2 hours of each day of the summer school experience.

The Common Core ELA Standards were integrated through lessons and activities from books created by Carol Marsh (2013), which included the scientific method, chemistry, and physics which aligned to all of the Common Core ELA Standards. Each activity was aligned to at least one of the Common Core ELA standards, but usually three to four standards were addressed daily. The science teacher used the lessons and activities from Marsh's (2013) series for approximately 2 hours of each day of the summer school experience. None of the curricula that this science teacher used during the summer school experience were teacher generated-lessons.

Data Analysis

For the data analysis of this study, SPSS was used for statistical calculations. The purpose this study was to determine whether or not there was a statistical significant increase in scientific literacy from the pretest to the posttest between the treatment group and the control group. The question was addressed using the mean difference between the pretest and posttest scores for each group and comparing the mean differences of statistical analysis using ANOVA with repeated measure within-between interactions.

Analysis of the difference of change in scores from pretest to posttest is necessary to determine if the effect of the treatment is significant. The difference in scores can be used for analysis between the two groups. The descriptive statistics for both the pre and posttest results describing the mean, standard deviation, and standard error using SPSS is presented in Table 1.

Table 1

Descriptive statistics for Scientific Literacy.

Variables	*n*	Mean	*SD*	SEM
Pretest	7	20.290	9.123	3.448
Posttest	7	21.140	13.347	5.045

Table 1 displays the descriptive statistics for both groups. The mean for the pretest was determined by obtaining the sum of all pretest scores and dividing by the number of students (*N*=7) who took the pretest. The mean for the posttest was determined by obtaining the sum of all posttest scores and dividing by the number of students (*N*=7) who took the posttest. The standard deviation addresses the connection between the set of scores to the mean of the sample. The ANOVA with repeated measure within-between interactions was used to compare the mean of the pre and posttest based on one independent variable, the integration of Common Core ELA Standards to the science curriculum. Because there were fewer than three repeated-measure conditions, the assumption of sphericity was not addressed in this ANOVA with repeated measures analysis (Field, 2013). The three assumptions in relation to the dependent variable, student posttest assessment scores, were as follows:

1. The dependent variable is normally distributed.
2. The two groups have approximately equal variance on the dependent variable.

3. The scores come from an independent sample.

The first assumption was analyzed using SPSS in relation to the Kolmogorov-Smirnov test and the Shapiro-Wilk test. The Shaprio-Wilk test is appropriate for small sample sizes (*N*<50), as represented in this study, in order to test for normality (Table 2). Table 2 illustrates the Shapiro-Wilk test was performed for both the pretest and posttest scores. The significance value for the pretest scores was 0.446, and the significance value for the posttest scores was 0.381. Because both sets of scores were not significant (>0.05), they were considered to have a normal distribution.

Table 2

Test of Normality

	Kolmogorov-Smirnov			Shapiro-Wilk		
	Statistic	*df*	Sig.	Statistic	*df*	Sig.
PreTest	0.227	7	0.200	0.917	7	0.446
PostTest	0.275	7	0.118	0.908	7	0.381

The second assumption was addressed by using the Levene's Test. The Levene's Test is significant if the significance value (labeled "Sig.") is less than 0.05, because the two variances are significantly different. If the Levene's test is not significant (Sig.>0.05), the two variances are not significantly different and can be considered approximately equal, and when the Levene's test is not significant, the second assumption is met. For the Levene's Test for Equality of Variance, the Sig was 0.101 for the dependent variables, which supports that the two groups have equal variance on the dependent variable. The two variances are not significantly different, and therefore, the second assumption is met. For the third assumption, the experimental design included participants under the same conditions, but it is expected that the behavior between different participants should be independent (Field, 2013). For the statistical analysis of this study, three of the original 10 subject's pretest scores were removed because they did not finish the treatment. These subjects did not complete the posttest.

Table 3 displays the descriptive statistics for both groups, including the original subjects who did not complete the treatment. The mean for the pretest was determined by obtaining the sum of all pretest scores and dividing by the number of students (N=10) who took the pretest. The mean for the posttest was determined by obtaining the sum of all posttest scores and dividing by the number of students (N=7) who took the post test.

Table 3

Descriptive statistics for Scientific Literacy including Original Subjects.

Variables	n	Mean	SD	SEM
PreTest	10	19.50	7.619	2.405
PostTest	7	21.140	13.347	5.045

Analysis of Variance

Scores related to performance on the scientific literacy assessment, both before the summer school experience and after, were analyzed using SPSS to determine analysis of variance with the treatment (summer school experience) as the between-subject factor. The performance score from pretest to posttest was determined by subtracting the pretest mean score from the posttest mean score. A positive performance score would show that the posttest score was higher than the pretest score, which was expected in order to support the alternative hypotheses.

The mean pretest score of 20.290 was subtracted from posttest score of 21.140. The value calculated of 1.120 indicates that the summer school experience improved scientific literacy assessment scores, which is a 5.5% increase in the mean for the test group. The performance score analysis does not control for the differences in pretest scores. An ANOVA was used to calculate further statistical information.

ANOVA Results

The first research question for this study was: What is the relationship between the Common Core ELA State Standards and scientific literacy? The null hypothesis for this research questions states there is no significant relationship between the Common Core ELA State Standards and scientific literacy. The alternative hypothesis is that there is a significant relationship between the Common Core ELA State Standards and scientific literacy. The null hypothesis of no significant relationship between the Common Core ELA State Standards and scientific literacy was tested by an analysis of variance on pre and posttest scores using summer experience as a within subject factor. Table 4 show the results of the ANOVA.

Table 4

ANOVA Analysis Research Questions

Source	*df*	*F*	η^2
Assessment Score	1.000	0.079	0.031
Error	6.000		

Note: Significance p=0.788

The descriptive statistical value, η^2, can be used to measure effect size for an analysis of variance with repeated measure. To address the first research question, the effect size of the performance scoring is η^2=0.031, which has a small effect. With an alpha value of 0.05, a k value of 2 represented the number for variables, a power of 0.80 leads to an estimated effect size value of η^2= 0.031. The results for performance scores on scientific literacy multivariate tests show significant values (0.788), which suggests that there is not a significant difference between performance score on the pre and posttest of scientific literacy, V=0.013, F (1.000, 6.000) = 0.079, $p > 0.05$.

A significant main effect was not found between the pre and posttest scores after the summer school experience or a reliable mean difference between performance scores on the pre and posttest of scientific literacy, F (1.000, 6.000) = 0.079, p = 0.788, η^2= 0.031, power = 0.80. The null hypothesis is retained, which states that no significant relationship exists between the Common Core ELA State Standards and scientific literacy.

The second research question for this study was: What is the relationship between an intensive science intervention and scientific literacy? The null hypothesis for this research question is that there is no significant relationship between an intensive science intervention and scientific literacy. The alternative hypothesis states there is a significant relationship between an intensive science intervention and scientific literacy. Using the results from the ANOVA with repeated measure (Table 4), there was not a significant main effect between the pre and posttest scores after the summer school experience nor a reliable mean difference between performance scores on the pre and posttest of scientific literacy, F (1.000, 6.000) = 0.079, p = 0.788, η^2= 0.031, power = 0.80. The null hypothesis is retained, which states that there is no significant relationship between an intensive science intervention and scientific literacy.

The third research question for this study was: Does teacher integration of the Common Core ELA State Standards into an intensive intervention affect scientific literacy? The null hypothesis states that teacher integration of the Common Core ELA State Standards into an intensive intervention does not have an effect on scientific literacy. The alternative hypothesis for this research question states that teacher integration of the Common Core ELA State Standards into an intensive intervention has an effect on scientific literacy. As stated previously, using the results from the ANOVA with repeated measure (Table 4), there was not a significant main effect between the pre and posttest scores after the summer school experience nor a reliable mean difference between performance scores on the pre and posttest of scientific literacy, F (1.000, 6.000) = 0.079, p = 0.788, η^2= 0.031, power = 0.80. The null hypothesis is retained, which states that there is no significant relationship between an intensive science intervention and scientific literacy.

Summary

The purpose of this study was to determine relationship between the alignment of curriculum and instruction in the content area of science to the Common Core ELA State Standards and the scientific literacy of middle school students and to determine if there was a statistically significant change in performance score due to participation in a science themed summer school experience which integrated the Common Core ELA State standards. The variables of this study were the integration of the Common Core ELA Standards, which is the single independent variable, and the scientific literacy skills of students, which was the dependent variable. The treatment was a summer school experience that included an intensive science intervention aligned to the Common Core ELA State Standards, and the control group were the students who had not previously participated in this summer school experience.

The first research question for this study was “What is the relationship between the Common Core ELA State Standards and scientific literacy?” The pretest and posttest scores were entered in SPSS to determine descriptive statistics, examine assumptions of normality and equal variance, and analysis using ANOVA. The ANOVA analysis was used to determine if the difference in the scores of the two groups was significant. Utilizing the results of the ANOVA with $p > 0.05$, there was no significant statistical difference between scientific literacy between the treatment group and the control group. The null hypothesis is retained, which stated that there is no significant relationship between the Common Core ELA State Standards and scientific literacy.

The second research question for this study was “What is the relationship between an intensive science intervention and scientific literacy?” The pretest and posttest scores were entered in SPSS to determine descriptive statistics and ANOVA. The ANOVA analysis was used to determine a significant difference in the scores of the two groups. Utilizing the results of the ANOVA with $p > 0.05$, there was no significant statistical difference for scientific literacy between the treatment group and the control group. The null hypothesis is retained, which stated that there is no significant relationship between an intensive science intervention and scientific literacy.

The third research question for this study was “Does teacher integration of the Common Core ELA State Standards into an intensive intervention affect scientific literacy?” The pretest and posttest scores were entered in SPSS to determine descriptive statistics and ANOVA. The ANOVA analysis was used to determine a significant difference in the scores of the two groups. Utilizing the results of the ANOVA with $p > 0.05$, there was no significant statistical difference for scientific literacy between the treatment group and the control group. The null hypothesis is retained, which stated that teacher integration of the Common Core ELA State Standards into an intensive intervention does not have an effect on scientific literacy.

In Chapter 5 of this study, the results of the study will be interpreted in relation to the literature review and the conceptual framework, limitations of the study will be discussed, and recommendations for future research will be introduced. In addition, the social change implications of the integration of the Common Core ELA State Standards into a science themed summer school experience will be discussed.

Chapter 5: Discussion, Conclusions, and Recommendations

The purpose of this study was to determine the relationship between the alignment of curriculum and instruction in the content area of science to the Common Core ELA State Standards and the scientific literacy of middle school students and to determine if there was a statistically significant change in performance score due to participation in a science-themed summer school experience which integrated the Common Core ELA State standards. The treatment was a summer school experience that included an intensive science intervention aligned to the Common Core ELA State Standards, and the control group were the students who had not previously participated in this summer school experience. Released items from the 2011 TIMSS that addressed concepts related to biology, chemistry, and physics were used to assess scientific literacy. The science curriculum used in the summer school experience was from the BSCS (2012) preview curriculum for middle school science. The Common Core ELA Standards were integrated through lessons and activities from books created by Carol Marsh (2013). The pre and posttests for the summer school experience were collected during the months of May and June, 2015. District personnel provided access to assessment data through the random sampling procedure described in Chapter 4. A total of seven pre and posttest scores of scientific literacy were used in a one-group pretest-posttest design that Shadish et al. (2002) recommended, where the pretest scientific literacy scores represented the control and the posttest scientific literacy score represented the treatment group.

The assessment scores of each group were used to determine if there was a statistically significant change in performance score due to participation in the summer school experience. No significant statistical difference in the scientific literacy performance score between the treatment group and the control group was found; however, an increase in scientific literacy scores was observed.

This chapter includes an interpretation of the findings in relation to how the integration of the Common Core ELA Standards into science instruction correlates with scientific literacy during an intensive intervention at a rural middle school. This chapter also includes a discussion of the limitations of this study, recommendations for future research, the implications for social change, and a conclusion.

Interpretation of Findings

The first research question for this study was “What is the relationship between the Common Core ELA State Standards and scientific literacy?” Using the results of the ANOVA, the null hypothesis was retained, which stated that there is no significant relationship between the Common Core ELA State Standards and scientific literacy. The second research question was “What is the relationship between an intensive science intervention and scientific literacy?” The ANOVA analysis was used to determine if there was a significant difference in the scores of the two groups, which showed no significant statistical difference for scientific literacy between the treatment group and the control group. The null hypothesis, which stated that there is no significant relationship between an intensive science intervention and scientific literacy, was also retained. The third research question for this study was "Does teacher integration of the Common Core ELA State Standards into an intensive intervention affect scientific literacy?" The null hypothesis for this question, which stated that teacher integration of the Common Core ELA State Standards into an intensive intervention does not have an effect on scientific literacy, was also retained.

In the one way ANOVA used for this study, as discussed in Chapter 4, I did not find a significant difference in performance scores between the treatment and control groups for any of the research question, so the null hypothesis was accepted for each. There was not a statistical significant difference in performance scores. However, the mean score difference value of the samples collected was calculated to be 1.120, a 5.5% increase in the mean for the test group, which indicates that the summer school experience improved scientific literacy assessment scores within this sample. This positive change suggest that while there seems to be educational research value to the use of a science summer school experience to improve scientific literacy for middle school students at a rural school, the length of the treatment must be increased. This extended treatment could lead to further increases in students' results. Another study would need to be conducted to ascertain the validity of this assertion.

Analysis of Findings in Relation to Research Literature

The findings of this study align with the research of Boyer (2006), Oliver (2013), and Thomson et al. (2010) that more research is needed about science education in rural schools. Though statistically insignificant, performance scores of students in this study in relation to the 2011 TIMS- released items places them into scientifically illiterate or nominal scientific literacy levels. According to the pre and posttest results of this study, there is a need to improve rural science education for rural communities. Some of the challenges, such as funding, that were observed at the host school aligns with challenges that Oliver noted in rural education. The challenge of funding transportation may have influenced student attendance and, therefore, the statistical significance of the study. As observed in this study, a lack of adequate control for comparison groups in the small, rural population of this study was a factor that affected the lack of statistical significance.

The full influence of the integration of Common Core State ELA Standards into science instruction has yet to be determined, but in this study, though statistically insignificant, I illuminated the potential of a positive impact of these standards on a science summer school experience. Conley (2014) suggested that the integration of the Common Core State Standards into science instruction may impact the literacy skills of students, and the findings from this study supports further research into this possibility. A focus on disciplinary literacy may improve student learning in a content area that may have been observed in this study with results described in Chapter 4 (Zygourius-Coe, 2012).

Performance scores from TIMSS placed students in this study into the levels of scientifically illiterate or nominal scientific literacy, the two lowest levels of scientific literacy. There is a need to improve scientific literacy in K-12 students (Bybee et al., 2009). A science intensive summer school experience may have a positive effect on developing scientific literacy for students, as measured by the TIMSS assessment. Though the results were found to not be statistically significant, additional research should be conducted to determine if teacher use of a science curriculum based on the 5E instructional model improves scientific literacy. However, as observed in this study, the increase may not be large enough to justify the expenditure of teacher or student time and resources of the school or district.

In this study, I did not find a statistically significant positive change due to an intensive intervention as seen in previous studies (Monahan, 2012; Morrow et al., 1997; Romance & Vitale, 2011). James-Burdumy et al. (2009) examined academic interventions and found a similar lack of significant effect as found in this study. As previously introduced, it is unclear whether or not the expenditure of teacher and student time as well as resources through academic intensive interventions or summer school experiences is productive.

Analysis of Findings in Relation to Theoretical Framework

The theoretical framework for this study was based on Bybee's (1997) scale of scientific literacy. Each level of scientific literacy increases the knowledge of scientific concepts as scientific literacy builds within the individual. The results of this study were statistically insignificant in relation to the theoretical framework of this study. Though these scores are not statistically significant, there is still a need to improve scientific literacy in K-12 students (Bybee et al., 2009). Student performance scores from the 2011 TIMSS-released items placed students into the levels of scientifically illiterate or nominal scientific literacy, with some students either increasing or decreasing their performance scores. As presented in Bybee's (1997) theoretical scale, factors of age may influence student performance because students in this study were enrolled in Grades 5 through 8 for the 2015-2016 school year. Unlike previous researchers who used Bybee's (1997) scale of scientific literacy, no statistically significant change in the student's scientific literacy levels was found in this study.

Confounding Variables

Confounding variables may have influenced the results of this study. This study was based on one science teacher's instruction during a summer school experience. This teacher had recently completed her first year as a middle school science teacher. The experience level of the instructor may have influenced how the curriculum was presented to students, which, in turn, could have influenced their scientific literacy scores. In fact, Duan et al. (2013) found that the curriculum teachers use for instruction, as well as their level of scientific literacy has a direct impact on the quality of education the student receives and, therefore, should be adjusted to support scientific literacy. The curriculum that the science teacher used for this study was still in the review process by the BSCS and had not been formally adopted by the school district. The science teacher who provided instruction for the summer school experience may not have had enough training in the implementation of this curriculum, which may have influenced the quality of instruction students received, as well as the content that was assessed using the 2011 TIMSS scientific literacy test items.

The host school's rural location and farming community may also have influenced student participation in the summer school experience. Though some transportation was provided, the limited funding for transportation may have influenced student participation in the summer school experience. Students who might have participated may have had obligations at home that prevented their attendance. These factors could have limited participation in the summer school experience to those students who had transportation and did not have significant obligations at home. Attendance for the summer school experience could not be predicted, which could have affected the quality of instruction because some students did not attend every day of the summer school experience.

Limitations of the Study

This study had several limitations. The first limitation concerned the research site. This study was limited to a single middle school, Grades 5-8, in one public school district located in a rural community. This single middle school does not represent all rural communities, and this summer school experience does not represent how other educators might have conducted an intensive intervention in science. Additional rural research sites would provide more data about the effects of science instruction examined in this study.

The second limitation was related to the sampling. Student participation in the intensive science intervention was voluntary, so the sampling of students did not represent the entire population of students within this rural community. All students in this middle school were invited to attend the science summer program, but participation was voluntary. A total of 14 students enrolled in the 2015 summer school experience, but only seven students completed the summer school science intervention. This low attendance affected the statistical aspects of this study because the sample size necessary for statistical significance required a minimal effect size of 0.5, an alpha value of 0.05 and a power of 80%, and the recommend sample size was 12 for this study.

The third limitation was the duration of the intervention. This study was limited to one teacher's science instruction during one intensive intervention for 4 hours per day, 4 days a week, for 4 weeks. The intervention may not have been long enough to observe a change in student performance scores between the pre and posttest.

The fourth limitation was the selection of the teacher participant. The administrator at the cooperating school selected the teacher who provided the intensive science intervention. The teacher may not have had enough training in the curriculum utilized for the summer school experience. The teacher of the summer school experience was also familiar with students in the study, which could have influenced student performance on the pre and posttest through teacher effects. Teacher effect can lead to variations in student performance, which may have been a factor in this study (Nye, Konstantopoulos, & Hedges, 2004).

Recommendations

Bringing attention to the need for scientific literacy and the integration of literacy skills into science instruction could encourage future research in several areas. This research could lead towards further validation of this study and additional data that supports the integration of the Common Core ELA Standards into science curriculum. Further research could also influence various science education stakeholders to design and implement legislation and policies to support the integration of the Common Core ELA Standards into science instruction in order to improve scientific literacy. The Common Core State Standards also include content specific literacy standards, which bring the value of such instructional approaches to the attention of science education stakeholders.

In relation to current instruction in mathematics, science, and English language arts, the new emphasis of the Common Core State Standards and the Next Generation Science Standards is on disciplinary practices and classroom discourse (Lee, Quinn, & Valdes, 2013). Science teachers play a significant role in encouraging and supporting literacy skill development while helping students to improve their ability to make sense of science. In order to support scientific literacy in the higher grades, a need to focus on supporting scientific literacy development in the lower grades definitely exists (Soobard & Rannikmae, 2011).

Future research utilizing quantitative data from other assessments of scientific literacy skills may provide more information for analysis when integrating the Common Core ELA Standards into science curriculum. The full effects of the recent adoption of the Common Core State Standards may not be known in relation to student performance on assessments in content areas beyond English language arts. Additional research into the impact of the Common Core State Standards on science curriculum and instruction might clarify the influence, if any, of this integration on student learning. A comparison of additional rural educational locations, as well as between urban and rural schools, might also help researchers identify possible factors that influence student performance on scientific literacy assessments in relation to literacy skill instruction. Additional research could examine the value of academic intensive summer schools, because the results of this study indicate no statistically significant change to student performance scores. To increase the reliability and validity of a future study, a larger sample size and a longer treatment period is recommended.

Implications for Social Change

This study has contributed to positive social change by advancing research about rural education in order to support the development of equitable science experiences for all students. Students in urban communities perform significantly higher on standardized scientific literacy assessments than students in rural areas (Thomson et al., 2010). By investigating different educational environments, such as rural schools, researchers may better support scientific literacy awareness and development for all educational environments. The results of this study show that a need to support science education in rural communities exists.

Citizens of the United States do not have a strong understanding of major concepts and skills related to science, technology, engineering, and mathematics (Bybee, McCrae, & Laurie, 2009; Impey et al., 2011; Symonds, 2004; Augustine, 2007 as cited by Khasnabis, 2008). One concern within the development of scientific literacy is that general science knowledge could become devalued as a result of pressing technological issues, even though those same issues are addressed within science and society (Bybee, McCrae, & Laurie, 2009).). Science education is compelled by a knowledge-based economy, which means that society relies on the ability of its members to determine the meaning and function of information (Aikenhead, Orpwood, & Fenshman, 2011). The purpose of scientific knowledge is directly linked to innovations in the fields of science. Society depends on the expertise of individuals in various science and technology fields as well as the general public and its ability to address science and technology situations in their daily lives. Knowledge in science and technology not only involves applying knowledge obtained in a science classroom, but also involves connecting the students to information needed in their out-of-school environments (Aikenhead, Orpwood, & Fenshman, 2011). Therefore, this study contributes to positive social change by helping members of society understand that they must provide fiscal, intellectual, and political support for science education by valuing scientific literacy and helping all students achieve a reasonable level of scientific literacy.

Conclusion

A clear need exists to improve scientific literacy skills for K-12 students (Bybee, McCrae, & Laurie, 2009). Both science curriculum and science instruction impact the development of these skills (Shwartz, Ben-Zvi, & Hofstein, 2006). Therefore, Bybee's

(1997) scale for scientific literacy is helpful to teachers by providing them with a structural approach for aligning and assessing science curriculum in order to develop these scientific literacy skills for K-12 students. More research about science education in rural school districts is also necessary to better meet the needs of that specific student population (Boyer, 2006; Oliver, 2013; Thomson et al., 2010).

The integration of the Common Core ELA Standards into science instruction has a positive impact on the development of literacy skills of students (Conley, 2014; Lee, Quinn, & Valdes, 2013; Zygourius-Coe, 2012). A focus on literacy skills within content areas such as science improves content area knowledge, general literacy skills, and academic performance (Lee, Quinn, & Valdes, 2013; Zygourius-Coe, 2012). The use of interdisciplinary skills in science encourages the development of scientific literacy in students (Ross, Hooten, & Cohen, 2013). Intensive academic interventions lead to significant positive change in student performance on assessments (Monahan, 2012; Morrow et al., 1997; Romance and Vitale, 2011). Therefore, more quantitative research examining the integration of the Common Core State Standards into science instruction is necessary to determine the full impact, if any, on the scientific literacy of students.

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Appendix: Data Use Agreement

This Data Use Agreement ("Agreement"), effective as of 10/31/14 ("Effective Date"), is entered into by and between Amber Struthers ("Data Recipient") and Elfrida Elementary School District ("Data Provider"). The purpose of this Agreement is to provide Data Recipient with access to a Limited Data Set ("LDS") for use in research in accord with the HIPAA and FERPA Regulations.

1. Definitions. Unless otherwise specified in this Agreement, all capitalized terms used in this Agreement not otherwise defined have the meaning established for purposes of the "HIPAA Regulations" codified at Title 45 parts 160 through 164 of the United States Code of Federal Regulations, as amended from time to time.

2. Preparation of the LDS. Elfrida Elementary School District shall prepare and furnish to Data Recipient a LDS in accord with any applicable HIPAA or FERPA Regulations

3. Data Fields in the LDS. No direct identifiers such as names may be included in the Limited Data Set (LDS). In preparing the LDS, Elfrida Elementary School District shall include the **data fields specified as follows**, which are the minimum necessary to accomplish the research: student demographic data, student AIMS test scores, student assessment scores obtained during the summer school research program.

4. Responsibilities of Data Recipient. Data Recipient agrees to:

   a. Use or disclose the LDS only as permitted by this Agreement or as required by law;

   b. Use appropriate safeguards to prevent use or disclosure of the LDS other than as permitted by this Agreement or required by law;

   c. Report to Data Provider any use or disclosure of the LDS of which it becomes aware that is not permitted by this Agreement or required by law;

   d. Require any of its subcontractors or agents that receive or have access to the LDS to agree to the same restrictions and conditions on the use and/or disclosure of the LDS that apply to Data Recipient under this Agreement; and

   e. Not use the information in the LDS to identify or contact the individuals who are data subjects.

5. Permitted Uses and Disclosures of the LDS. Data Recipient may use and/or disclose the LDS for its Research activities only.

6. Term and Termination.

   a. Term. The term of this Agreement shall commence as of the Effective Date and shall continue for so long as Data Recipient retains the LDS, unless sooner terminated as set forth in this Agreement.

   b. Termination by Data Recipient. Data Recipient may terminate this agreement at any time by notifying the Data Provider and returning or destroying the LDS.

   c. Termination by Data Provider. Data Provider may terminate this agreement at any time by providing thirty (30) days prior written notice to Data Recipient.

   d. For Breach. Data Provider shall provide written notice to Data Recipient within ten (10) days of any determination that Data Recipient has breached a material term of this Agreement. Data Provider shall afford Data Recipient an opportunity to cure said alleged material breach upon mutually agreeable terms. Failure to agree on mutually agreeable terms for cure within thirty (30) days shall be grounds for the immediate termination of this Agreement by Data Provider.

   e. Effect of Termination. Sections 1, 4, 5, 6(e) and 7 of this Agreement shall survive any termination of this Agreement under subsections c or d.

7. Miscellaneous.

   a. Change in Law. The parties agree to negotiate in good faith to amend this Agreement to comport with changes in federal law that materially alter either or both parties' obligations under this Agreement. Provided however, that if the parties are unable to agree to mutually acceptable amendment(s) by the compliance date of the change in applicable law or regulations, either Party may terminate this Agreement as provided in section 6.

   b. Construction of Terms. The terms of this Agreement shall be construed to give effect to applicable federal interpretative guidance regarding the HIPAA Regulations.

c. <u>No Third Party Beneficiaries.</u> Nothing in this Agreement shall confer upon any person other than the parties and their respective successors or assigns, any rights, remedies, obligations, or liabilities whatsoever.

d. <u>Counterparts.</u> This Agreement may be executed in one or more counterparts, each of which shall be deemed an original, but all of which together shall constitute one and the same instrument.

e. <u>Headings.</u> The headings and other captions in this Agreement are for convenience and reference only and shall not be used in interpreting, construing or enforcing any of the provisions of this Agreement.

IN WITNESS WHEREOF, each of the undersigned has caused this Agreement to be duly executed in its name and on its behalf.

DATA PROVIDER	**DATA RECIPIENT**
Signed: ______________________________	Signed:
Print Name: __________________________	Print Name:
Print Title: ___________________________	Print Title: